

Fuzzy Logic Models for Non-Programmed Decision-Making in Personnel Selection Processes Based on Gamification

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Abstract. Non-programmed decision-making is an activity that requires a number of methods to try to capture the rational behaviour of an aspirant in situations of uncertainty. Thus, there is a varied list of attributes, methods, and mechanisms that are intended to describe the way in which aspirants can be profiled. However, this modelling proves to be complex if it is approached in scenarios based on game mechanics from gamification. For this reason, the following article aims to contribute to the processes of selection of personnel delimited only to the making of non-programmed decisions, through the implementation of game mechanics. In order to model this selection, the purpose of the following study is to carry out the formulation of inference rules based on fuzzy logic in order to capture the tacit transfer of certain types of information in personnel selection processes and to determine aspects that allow the shaping of aspirants. Finally, the results and conclusions obtained are presented.

Key words: gamification, decision making, fuzzy logic, psychological test. step-by-step.

1. Introduction

The staff selection process is considered “a critical process in the integrated management of human resources in organizations given it strongly influences the effectiveness of management processes that occur after the selection” as it is presented by Salgado and Moscoso (2008). The authors highlight that the activities that are usually carried out in the selection processes deserve reconsideration. This is because doubts have been identified about the effectiveness of applying a written test that makes clear the pretensions of what it’s been investigating, in addition to the fact that they take long application times.

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For his part, Highhouse (2008) mentions that the traditional unstructured interview is more effective than other procedures involving resolutions using paper and pencil. However, most companies perform these procedures more frequently (handmade, usually multiple-choice). This is complemented by the fact that human resources professionals are aware of the limitations of the informal interview, which is mentioned by Rynes *et al.* (2002) and Vakkayil *et al.* (2017). Similarly, authors such as He and Gong (2010) agree with these positions, as they support the following limitations in some methods of recruitment: false or incorrect information can be obtained during the background investigation; interviews need to be applied by experts trained to not be carried away by a certain bias; and there is a high probability of false positives with polygraphs. In addition, the procedure is long and arduous, and in some countries, it is not legal to administer polygraphs or they have no regulation.

Gamification is an unexplored area in issues related to selection of personnel. Authors like Burke (2012) and Kim (2015), in addition to mentioning the topic of employee performance, summarize gamification as the trend of using gaming mechanics in other non-entertainment environments such as innovation, marketing, training, health, and social change.

In the literature we can find different decision making approaches based on fuzzy tools, see Capuano *et al.* (2017), Liu *et al.* (2017), Zhang *et al.* (2017), Pérez *et al.* (2010), Cabrerizo *et al.* (2013, 2014). One of the motivations of the following article is to raise, from the point of view of fuzzy logic, a series of rules of inference that can be linked to the management of the profiles of the aspirants to top management positions (players) through a test based on gamification. The characters that support the profiling of aspiring players within the game were defined from two conceptual notions: the first notion, related to an organizational theory about leadership in which employees are classified as eagles or ducks, and the second notion, which describes human behaviour from five global dimensions: anxiety, independence, tenacity, extraversion, and self-control. All these features of the game model developed are specified in Albadán Romero *et al.* (2016), with emphasis on the gamification details. Finally, it is intended to propose a series of guidelines that facilitate the modelling of profiles in function of the non-programmed decision-making supported in the gamification.

The paper is organized as follows: Section 2 presents the background, where the rules that define mathematical modelling for non-programmed decision-making are discussed, and the characteristics about gamification are also presented. Section 3 defines the method of work based on the methodology used in our study. Section 4 presents the analysis of the results obtained from a case study defined in a test based on gamification. Section 5 presents the discussions, and, finally, section 6 presents the conclusions and recommendations for future work.

2. Background

2.1. Decision-Making

The upper cognitive layer of the brain contains almost four dozen fundamental cognitive processes, as established in Wang *et al.* (2003), which are categorized into two large groups: subconscious processes and conscious processes, each group with two layers as modelled in Albadán Romero and Gaona-García (2015). There are several proposals of benefits of decision-making in cognitive tasks and psychiatric process: Grant *et al.* (2011), Deegan and Drake (2006), and Duncan *et al.* (2010). For non-programming decision-making for the personal selection process, the following sources have proposals: Nicolas (2004), McKenzie *et al.* (2011), and Kao *et al.* (2012). Still there are no literature reviews supported by gamification. By making an analysis based on decision-making, it is necessary to detail that the conscious processes are characterized by being acquired and moulded and can be controlled deliberately by will, aspirations, and motivations. Within conscious processes, decision-making is part of higher cognitive processes. The authors refer to other functions of the brain that are classified in the upper layer, among which are reasoning, analysis, and quantification, among others.

2.2. Mathematical Models of Decision-Making

There is a variety of strategies developed from the traditional perspective, as well as from game theory, cognitive science, management sciences, and economics, that lead to different mathematical models about decision-making. Under these approaches, authors like Wang *et al.* (2004) present a taxonomy of models and decision-making criteria with four categories. Table 1 shows the taxonomy mentioned.

The first two categories (intuitive and empirical) are in the path of human intuitive cognitive psychology and therefore do not have a rational model to explain such selection criteria. Therefore, the mathematical modelling is not detailed in this category of strategies; however, the model proposed here to characterize non-programmed decision-making processes involves capturing actions that determine whether the player (who makes the decisions) appealed to one of the strategies mentioned. The following is a preliminary mathematical model followed by an illustration of some of the main mathematical models of decision-making, which are implemented mainly in decision support systems.

2.3. Preliminary Mathematical Model

In this section, we will work on the fundamental and general mathematical models of decision-making addressed in Wang *et al.* (2004). In a first approximation, the selection axiom states that there exists a function of selection for some non-empty collection of sets of non-empty disjoint alternatives indicated in (1):

$$A_i \mid A_i, \quad i \in I, \quad A_i \subseteq U, \quad \forall y, A_i \neq \emptyset. \quad (1)$$

Table 1
Taxonomy of decision-making strategies and criteria Wang *et al.* (2004).

Strategy	Criteria
1. Intuitive	
a. Arbitrary	Based on the easiest or familiar selection
b. Preferential	Based on propensity, hobby, tendency, expectation
c. Common sense	Based on axioms and judgements
2. Empirical	
a. Trial and error	Based on exhaustive tests
b. Experimental	Based on the results of experiments
c. Experience	Based on existing knowledge
d. Consultor	Based on professional consultation
e. Estimate	Based on an approximate assessment
3. Heuristic	
a. Principles	Based on scientific theories
b. Ethics	Based on philosophical criteria and beliefs
c. Representative	Based on common thumb rules
d. Availability	Based on limited information or local maxima
e. Anchor	Based on a presumption or bias and its justification
4. Rational	
4.1 Static	
a. Minimum cost	Based on the minimization of energy, time and money
b. Maximum benefit	Based on the maximization of functionality, reliability, quality, usability
c. Maximum utility	Based on cost-benefit ratio
d. Certainty	Based on maximum chance, statistical data
e. Risks	Based on minimal loss or regret
f. Uncertainty	
g. Pessimistic	Based on minimax
h. Optimistic	Based on maximax
4.2 Dynamic	
a. Interactive Events	Based on automatons
b. Games	Based on conflicts
c. Zero Summation	Based on the summation (gain + loss) = 0
d. Not Zero Summation	Based on the summation (gain + loss) = 0

Therefore, we have a function as shown below in (2):

$$f : \{A_i\} \rightarrow A_i, \quad i \in I. \quad (2)$$

That function is considered a selection function if we obtain as a result an element, which would represent a selected alternative, which belongs to a set of alternatives A_i , as reflected in (3):

$$f(A_i) = a_i, \quad a_i \in A_i. \quad (3)$$

The set of alternatives, which is characterized because each of the alternatives is different from the others but all belong to a set of possible alternatives, is expressed in (4):

$$A_i, A_i \cap A_{i'} = \emptyset, \quad i \neq i', \quad i \in I, \quad i' \in I, \quad A_i \subseteq U. \quad (4)$$

From (3), we can obtain the formal specification of a decision (d), which is a selected alternative (a_i) from a non-empty set of alternatives (A_i) and which is obtained when a set of criteria is added for the selection of alternatives (C), which is expressed in (5):

$$d = f(A_i, C). \quad (5)$$

Finally, the cognitive decision-making process is modelled as a Cartesian product between the selection alternatives (A_i) and established criteria (C) to achieve a given decision goal, as expressed in (6):

$$d = f : A_i \times C \rightarrow A_i, \quad i \in I, \quad A_i \subseteq U, \quad A_i \neq \emptyset. \quad (6)$$

The possible number of decisions (n) can be determined from the sizes of A_i and C.

$$n = \#(A_i) \cdot \#(C) \quad (7)$$

where # is a cardinal calculation on the sets. If any of the two sets, selection alternatives, or criteria is equal to zero, the decision cannot be derived.

2.4. General Mathematical Models

Decision theory covers diverse models and formal methods to carry out an analytical and systematic approach to studying the optimization of selection processes. An already well-known approach is the operations research with its different strategies and problem-solving models, as evidenced by Hillier *et al.* (2005), who approach this discipline as an application to “conducting and coordinating activities in an organization” and authors Al-Azab and Ayu (2010), who explain some of the models that are most commonly implemented to make a correct decision in environments of certainty, risk, uncertainty, with experimental information, and so on.

To easily understand each of the criteria presented below, one must start from the premise that in order to make a decision, you must have several alternatives (for example: X, Y, Z). These alternatives that will solve the problem will have different values or results, which can be influenced by the characteristics of the environment where the decision will be made (for example: $X_1, X_2, X_3, Y_1, Y_2, Y_3, Z_1, Z_2, Z_3$).

2.4.1. Wald Criterion (Minimax)

The Wald criterion is a decision-oriented criterion to maintain a “prudent” position. It basically consists of taking each alternative solution, assigning it the worst possible result, and choosing the best one from among them.

Initially, we will have a set of alternatives A_i , from which we must choose the one with the lesser weight, as evidenced in (8), where r_{ij} implies having a set of weights by a single alternative. For its part, m_i is the set with the lowest weights obtained by each alternative.

$$A_i = \text{Min } r_{ij} = m_i. \quad (8)$$

Subsequently, we take the set of the lower weights, or worse results, of each alternative to select the largest of them, as described in (9):

$$d = \text{Max}(\text{Min } r_{ij}) = \text{Max}(m_i). \quad (9)$$

It is considered a convenient method when the decision-maker expects the worst condition for himself and tries to find the solution to facing the opposition, according to Xiaogang and Qijie (2011), who keep in mind that research in these decision situations is also called game theory. In Radner (2015), it is mentioned that the Wald criterion, also known as the minimax rule, is the most promising candidate method for rational behaviour in situations that consider uncertainties.

2.4.2. Maximax Criterion

The maximax criterion is the counterpart of the Wald criterion and characterizes an “optimistic” or “risky” orientation towards decision-making. Radzian *et al.* (2010) synthesize it as the strategy that is intended to maximize the gain. Basically, each alternative will be taken and assigned the maximum possible value, and from these maximum values, the best is selected again.

This starts from an initial set of alternatives A_i , which can contain several weights, and from them, the best one must be chosen, the greatest one being presented in (10) r_{ij} implies having a set of weights by a single alternative. For its part, m_i is the set with the highest weights obtained by each alternative.

$$A_i = \text{Max } r_{ij} = M_i. \quad (10)$$

From the set of the best weights, or better results, of each alternative m_i , the greater of them is selected, as expressed in (11):

$$d = \text{Max}(\text{Max } r_{ij}) = \text{Max}(M_i). \quad (11)$$

The following criteria present mathematical processes that involve tabulating, graphing, or making use of decision support systems. Therefore, it is pertinent to clarify that the present work will not be detailed about that, as it is being assumed that the study of non-programmed decision-making refers to a decision-maker who would not carry out extensive processes or rely on applications or software in general.

2.4.3. Hurwicz Criterion

The Hurwicz criterion is a decision-making criterion that is found in the middle of the Wald and maximax criteria. The decision-maker evaluates the degree of pessimism with a coefficient called α .

With the coefficient, a convex linear combination between the best and worst results for each alternative is determined, and the best one is chosen. (12) includes the coefficient α of the degree of pessimism in each term of the expression.

$$A_i \rightarrow C_i = \alpha m_i + (1 - \alpha)M_i. \quad (12)$$

Then, the decision is obtained from the highest value after the combinations, as evidenced in (13):

$$d \rightarrow \text{Max } C_i = \text{Max } \{ \alpha m_i + (1 - \alpha) M_i \}. \quad (13)$$

In this criterion, the coefficient of the degree of pessimism becomes an indispensable element. In the research of Van Nam *et al.* (2009), the authors demonstrate that if there is no information on the probability of distribution for α , it is reasonable to assume that these values are evenly distributed in the interval $[0, 1]$. For their part, in Al-Azab and Ayu (2010), the authors illustrate the development of the combinations by means of a table where they develop each of the expressions expressed in (12) and later graphically.

2.4.4. Savage Criterion

This criterion measures the opportunity cost of an erroneous decision using the minimax criterion. It requires the elaboration of an array of regrets, which is characterized as the difference between the best results for each alternative solution with each of its corresponding results. After obtaining the matrix, it makes use of the criterion of Wald, but takes into account that the matrix is of unfavourable results.

2.4.5. Laplace Criterion

The Laplace criterion transforms the uncertainty problem into a risk one by assigning an equiprobability to the solution alternatives and rests on the criterion of the mean value to solve it. (14) expresses the Laplace criterion, where, if there are four possibilities, the probability P will be $\frac{1}{4}$.

$$\sum P(A_i) = \sum \frac{1}{m}(A_i), \quad \text{for each } i = 1, 2, 3, \dots, m. \quad (14)$$

If the above equation is related to the Wald and Maximax criteria, the difference is that the two previous ones extract the highest or lowest value for each solution alternative. On the other hand, in Laplace's criterion, the probability for each possible result is multiplied, and a summation is performed for each alternative. That is, if a solution alternative has four possible values or results, you will get four terms, which will be added together. Subsequently, since we have summations for each alternative solution, we choose the maximum value of that set, as it is shown in (15). If we have three alternatives, the set will be conformed to those values.

$$d \rightarrow \text{Max } A(M_i). \quad (15)$$

2.4.6. Linear Programming

Authors like Anderson *et al.* (2015) mentioned that the problems for which the method of linear programming was developed correspond to real situations in which it is intended to maximize or minimize a linear function to linear constraints that limit the degree to which the target can be reached. As becomes evident in the development of Al-Azab and Ayu (2010), this method involves the establishment of inequalities, graphic representation, and selection of the preferred value.

2.4.7. *Multi-Criteria Decisions (Multi-Objective Analysis)*

A multi-criteria approach is used when decision problems are presented with specific objectives. This criterion is also known as vector optimization and is based on explicit criteria to evaluate different alternatives.

In general terms, decision variables are established, the model is presented with its constraints (inequalities), graphically represented, and it is possible to use linear programming applications to find the value of the objective function.

2.4.8. *Sequential Decisions*

Sequential decision-making consists of a situation in which decision-making is carried out from successive observations of a process, as discussed in Diederich (2015). The procedure to determine when to stop taking observations and at what point to continue determines the optimal stop rule and depends on the specific assumptions about the situation: knowledge of the distribution of observations, the distribution properties of observations, if the number of possible observations is delimited or unlimited, the sampling procedure, and the cost function for each observation.

2.4.9. *Game Theory*

Game theory is a set of techniques for making decisions in conflict situations based on the elaboration of a formal matrix that makes it possible to understand the conflict and its solution alternatives.

What is interesting when approaching this perspective is that strategies are highlighted to study the ideal choice when the decisions depend on the others involved, making use of arguments of rationality and present restrictions. It is considered appropriate to apply this strategy when you do not have full control of the factors that influence a result. The in-depth study of this area of knowledge would make developing a whole collection of academic products possible, so it is not the intention of this work to delve into this area.

2.5. *Gamification*

The term gamification represents the extrapolation of game mechanics in non-entertainment contexts to engage the user and solve problems as explained in Burke (2012) and Zichermann and Cunningham (2011). As said in Domínguez *et al.* (2013), an accurate definition of gamification is a “challenge” because it is an emerging concept, and this is because it has grown rapidly in recent years, as detailed in Seaborn and Fels (2015). However, as is evident in Kapp (2012), the elements that constitute and define gamification are nothing new, originating from game mechanics. In order to go into detail, a definition that is considered important for obtaining several components of gamification is that “gamification is the use of game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning and solve problems” which is proposed in Kapp (2012).

For their part, authors like Bruzzone *et al.* (2014) detail the importance and potential of serious games for the identification, development, and learning of soft skills. In interaction

Table 2
Classification of skills measured by serious games in companies. Source Riedel and Hauge (2011).

Soft skills	Hard skills
Teamwork	Products/Knowledge Services
Communication	Sales and Customer Service
Interpersonal skills	Discipline-Based Training, e.g. Finance, Purchasing, Stock Control
Negotiation Skills	Project Management
Creativity	Decision-Making Skills
Collaborative Skills	Innovation and Risk Management
Learning	Health and Security
	Legal Compliance/Regulation

with a game, soft skills correspond to the ability to catch sight of the details of a scenario or the identification of the missing elements in a set of information. Riedel and Hauge (2011) illustrate a classification of skills that are measured by serious games, which differs from what Bruzzone *et al.* (2014) expose, because not only are soft skills measured, but hard skills are as well. The study was conducted in the top 100 organizations on a list drawn up by a UK-recognized journal. Table 2 presents a classification of the abilities that are measured by the serious company games made by Riedel and Hauge (2011), and then the methodological elements related to the investigation are presented.

3. Methodology

In order to define a systematic method for our study as provided in the introduction section, we used an experimental research method. First, we defined an experimental research method based on mathematical modelling in order to measure and define rules for a fuzzy logic system. Then, we applied a quasi-experimental research method in order to define the profiles of the participants, based on Teddlie and Tashakkori (2006). Next, we made these rules apply to the game to validate the results found in the exploration process for our study case. Finally, derived from the participation results, we made an experimental research method to validate the results according to the profiles and roles defined.

In particular, four phases were proposed in the work methodology, covering the basic aspects of research: analysis, exploration, application, and validation. The details of each of these phases are illustrated below in Fig. 1.

The analytical phase focused on the mathematical models discussed in the background section. It was hoped, therefore, to have enough basis to set up the inference rules of fuzzy logic, which are exposed in the next phase, the exploratory phase, inasmuch as it is intended to discuss a conceptual connection between the inference rules and profile management in personnel selection processes, topics with great detail for work in future research.

Subsequently, an applied phase was projected, through the definition of a case study, that contains the design of several interactions, covered by gamification concepts that are detailed in earlier studies, as mentioned before. In this way, metrics and indicators are thrown in to confirm, in the last phase, how close the model was to the inference rules in order to get profiles during selection processes.



Fig. 1. Methodology used in research.

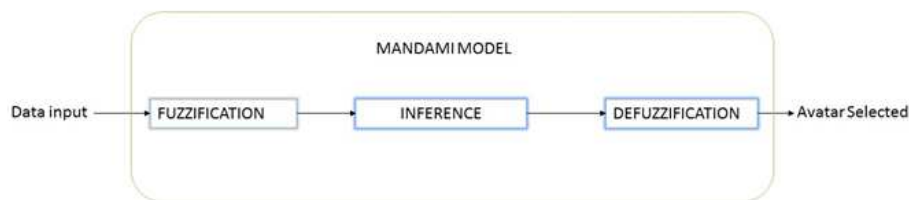


Fig. 2. Fuzzy logic model to determine the avatar according to the obtained scores.

4. Proposed Model from Fuzzy Logic

There are several proposed models based on the fuzzy logic system for studies in the field of decision-making like those in Zeng *et al.* (2016) and Shouzhen (2016); however, there is no research or literature review available related to the use of the gamification model. Using the Matlab Fuzzy Logic Toolbox, a Mandami fuzzy logic system was created to perform the process illustrated in Fig. 2. First, criteria were established to evaluate the results obtained by the players in each of the 10 attributes: adaptability, self-control, conviction, dynamism, initiative, integrity, leadership, perseverance, persuasion, and planning. The range was classified with values between 0 and 100, such that the values between 0 and 50 were classified as bad, the values between 50 and 80 were classified as average, and 80 to 100 were high.

4.1. Proposed Rules for the Avatar

To classify the results into avatars, five rules of inference were used, as shown in Table 3, one for each possible avatar (monkey, eagle, owl, duck, and jaguar). This was done so that when entering the results obtained during the tests by each player, the model evaluates the results with fuzzy logic, allowing it to determine to which avatar the skills shown by the player correspond.

So, using the minimum criterion in the 'and' method in the model, the rules are described as follows:

Table 3
Inference rules for avatars.

	Eagle	Jaguar	Owl	Duck	Monkey
Adaptability	HIGH	AVERAGE	AVERAGE	HIGH	AVERAGE
Self-control	LOW	LOW	HIGH	HIGH	AVERAGE
Conviction	HIGH	AVERAGE	AVERAGE	LOW	AVERAGE
Dynamism	AVERAGE	AVERAGE	LOW	AVERAGE	HIGH
Initiative	HIGH	HIGH	LOW	AVERAGE	HIGH
Integrity	LOW	LOW	HIGH	AVERAGE	AVERAGE
Leadership	AVERAGE	HIGH	AVERAGE	AVERAGE	AVERAGE
Perseverance	AVERAGE	AVERAGE	HIGH	HIGH	AVERAGE

- If (Adaptability is High) and (Self-Control is Low) and (Conviction is High) and (Dynamism is Average) and (Initiative is High) and (Integrity is Low) and (Leadership is Average) and (Perseverance is Average) and (Persuasion is Low) and (Planning is High) → Avatar is Eagle.
- If (Adaptability is Average) and (Self-Control is Low) and (Conviction is Average) and (Dynamism is Average) and (Initiative is High) and (Integrity is Low) and (Leadership is High) and (Perseverance is Average) and (Persuasion is High) and (Planning is Average) → Avatar is Jaguar.
- If (Adaptability is Average) and (Self-Control is High) and (Conviction is Average) and (Dynamism is Low) and (Initiative is Low) and (Integrity is High) and (Leadership is Average) and (Perseverance is High) and (Persuasion is Average) and (Planning is Average) → Avatar is Owl.
- If (Adaptability is High) and (Self-Control is High) and (Conviction is Low) and (Dynamism is Average) and (Initiative is Average) and (Integrity is Average) and (Leadership is Average) and (Perseverance is High) and (Persuasion is Average) and (Planning is Low) → Avatar is Duck.
- If (Adaptability is Average) and (Self-Control is Average) and (Conviction is Average) and (Dynamism is High) and (Initiative is High) and (Integrity is Average) and (Leadership is Average) and (Perseverance is Average) and (Persuasion is High) and (Planning is Low) → Avatar is Monkey.

4.2. Definition of Rules for Strategies for Non-Programmed Decision-Making Activities

The proposal elaborated in this study is based on the decision-making strategies presented in Wang *et al.* (2004) as presented in Table 4 and the mathematical models discussed in Al-Azab and Ayu (2010) to propose a model of the activities of non-programmed decision-making. The mathematical criteria must allow for the measurements of or give indicators of the abilities to be demonstrated by the player who will make the respective decisions. The result of this analysis is shown in Table 4.

These eight strategies were the most registered in the developed web application. Their relationship to the graphs of the results is given, in which these strategies determined the decisions made by the candidates in the selection process, while they played a game directing a herd of animals with certain goals. In the future, greater potential can be ob-

Table 4
Relationship between non-programmed decision-making activities and strategies.

MD strategy: mathematical model	
Certainty (probabilities):	$\sum P(A_i) = \sum \frac{1}{m}(A_i)$, for each $i = 1, 2, 3, \dots, m$
Pessimistic:	$d = \text{Max}(\text{Min } r_{ij}) = \text{Max}(m_i)$
Optimistic:	$d = \text{Max}(\text{Max } r_{ij}) = \text{Max}(M_i)$
Minimum Cost, Maximum Benefit	
Arbitrary, Preferential, Common Sense	

tained from this determination, because for now, it only delimits them of all the strategies presented in Table 1, according to the characteristics of gamification addressed in the investigation.

Strategies that are not described by some mathematical criteria imply a parameterization based on the user interaction in the gamified environment; for example, the “test and error” or “experimental” strategy can be captured from the number of choices repeated by a user or the number of times a particular action is repeated. Meanwhile, “Minimum cost” and “Maximum benefit” will depend on how the information is delivered to the user.

4.3. Key Metrics Applied to the Game

The following are the indicators or metrics under which the psychological competencies associated with non-programmed decision-making are modelled:

- **Dynamism:** given by the progress curve of the click/min ratio in terms of reviewing indicators of preservation of attention to and action in the game, as it becomes a repetitive activity in which the player goes in search of food and simultaneously responds to the eventualities that appear. So, we apply the (16) equation to get the click variation, minute by minute, from which we obtain averages. In addition, a three-stage discrimination of the whole game is performed, with the same logic, to verify more precise details that are thrown in the profile of the player:

$$D = \frac{\sum_{i=0}^{m-1} Pc_{i+1} - Pc_i}{m - 1} \quad (16)$$

where D is the value of the dynamism obtained, Pc is the sum of partial clicks that were recorded for each minute, m is the number of minutes played, in this case 15, and i , is the iteration for each minute.

- **Planning:** given by the relation between order of execution and control of the members of the herd in terms of checking to see if one executes the actions in a specific order, waiting for a parallel completion of all the elements, or executes actions at random times, without maintaining a specific order. (17) details the procedure for obtaining the planning metrics, obtaining an average of the variations of the order in which the members are sent for food. In this case, the absolute value is used because it is required to determine the variation regardless of whether the slope from one point to another is positive or negative.

$$P = \frac{\sum_{i=0}^{E-1} |N_{i+1} - N_i|}{S - 1} \quad (17)$$

where P is the value obtained from planning, N is the number of members sent for food, E is the length of the vector containing the totality of the records of membership sends, and i , is the iteration for each minute. On the other hand, this planning metric is affected by the request for information before executing an action, which was described in the Challenges section and specified in (18).

$$S = \frac{TR}{TE} \quad (18)$$

where S is the average requests for information to support decision-making, obtained from operating total requests, TR , on the total random events that were generated, TE .

- Self-control: given by the average of the times an action took to be taken, after the eventuality was generated, as detailed in (19). Also described by the factor of requesting information before acting, as described above.

$$ATa = \sum_{i=1}^a \frac{at_i}{a} \quad (19)$$

where ATa is the average of the duration of the actions, obtained from adding each of the times of actions, at , to the number of actions, a .

- Conviction: due to the number of combats versus withdrawals of a member at the moment of presenting an eventuality that was randomly generated, which is represented in (20). This metric is demarcated with more relevance in the moment of responding to major challenges proposed with greater weight to collect, but more probability to lose the member.

$$AF = \frac{TF}{TE} \quad (20)$$

where PC is the average of fights, obtained from operating the total of fights, TF , on the total of events, TE .

- Perseverance: given by the percentage of reaching the final objective in relation to certain periods of time. (21) presents the modelling to see if its intention to reach the goal was maintained in a similar way to the measurement of dynamism. Additionally, at the end of the game, as it is unlikely that you have reached the requested amount of food, a message will appear if you wish to continue until the indicated amount is reached, under the persuasive message described in the previous section. So, the decision to persist and continue to reach the goal or to give up and stop playing contributes to determining the perseverance of the player.

$$P = \sum_{i=0}^{m-1} \frac{Tw - Cw}{m - 1} \quad (21)$$

where P is the value of the perseverance obtained, Tw is the total weight to be reached, as the target of the scenario, Cw is the amount of current weight the player has achieved, m is the number of minutes played, and i , is the iteration by each minute.

5. Results Analysis

In the game, the initial scenario is an environment where the player must parameterize basic skills as a moment of self-evaluation. Subsequently, in the main scenario of the game, the capture of several events that are generated during the interaction of the player is highlighted. These events allow the characterization of the decision-making processes according to the approach made in Albadán Romero *et al.* (2016, in press), where a small group of psychological capacities was chosen starting from the base, resulting in the following ones being chosen: 1) dynamism, 2) planning, 3) self-control, 4) conviction, and 5) perseverance.

During a trip back and forth, random events are generated in which the player must make decisions, which are then stored. The decision might be to escape and return to the lair, or you can fight against the opponent. That combat is solved by probabilities (`Math.random`) and under comparison against a threshold, the outcome of the combat (win or loss) is determined. In the first outcome, the tour continues to the lair and food is added to the total. If the combat is lost, the member's health decreases and the trip is lost. The capture of information from the events given in the interaction in the game is in relation of determining indicators of the psychological competences described above, which will allow for the consolidation of the characterization of the processes of non-programmed decision-making.

Approximately 50 tests were carried out, with people of different academic characteristics (30 professionals and 20 university students), to test the interaction in the game and to corroborate how the reports are obtained, contributing to the establishment of the candidate profile. Each test generates a small description of the profile of the player/applicant, and linked to the textual description is a statistical report of the psychological skills already mentioned. Initially, the report of self-evaluation of psychological skills, with the traits that the person pretends to show as the most outstanding in his personality, were created. As an example, Fig. 3 shows a comparison in relation to the psychological competence of dynamism. This is observed in the upper part, where the player maintains, in general terms, an ascending level of attention. On the other hand, in the lower part of the figure, a descending level of attention is observed. These opposing cases are textually described in the candidate's profile and supported by the corresponding graphs.

In terms of planning, the following is the curve with the sequence of points that identify the profile of a methodical person who carries out actions in a sequential way and waits for the complete conclusion of all actions in progress to start again. However, if a player executes actions without any order, it denotes a person who, in the face of unexpected events, manages to deal with them as they arise without performing sequential actions. These two opposite situations are evident in the planning curve in Fig. 4.

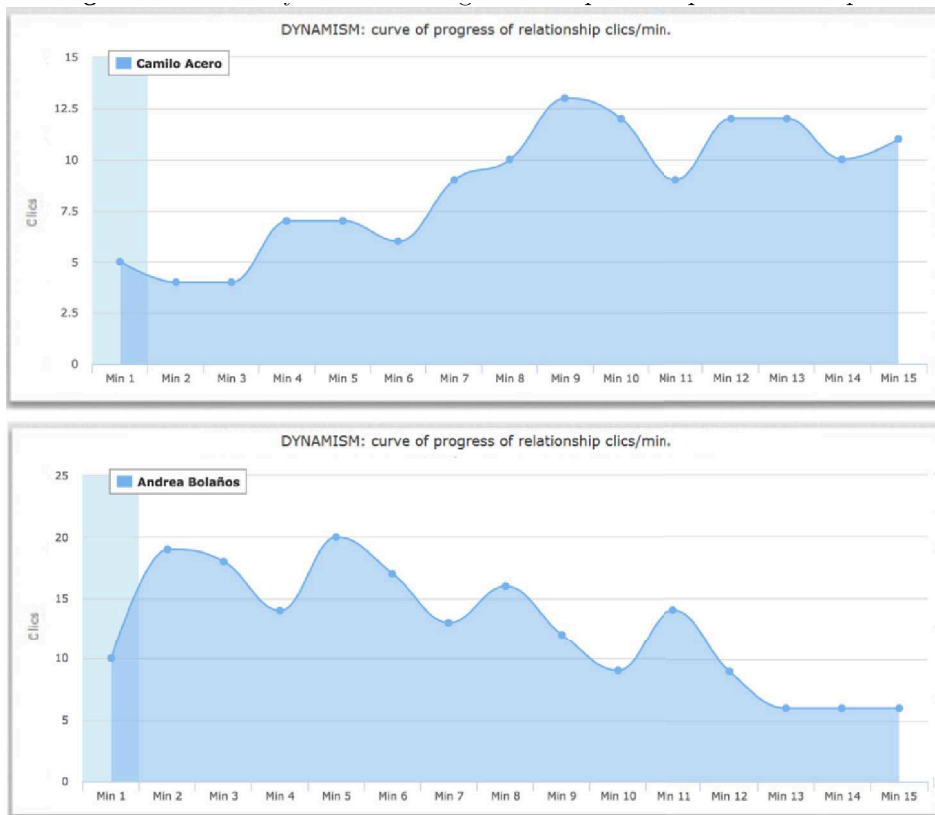


Fig. 3. Curve of dynamism arranged in the profile report of the aspirant.

6. Discussions

The gamification of the tests proves to be a very attractive proposal and offers great support for the processes of personnel selection. Nevertheless, to carry out the capture of events for non-programmed decision-making, it is necessary to model more psychological competences that allow for a real estimate for tests that are given to applicants in real time. There are few proposals in this area of human resources, despite proposals such as those presented in Guenaga *et al.* (2014) and Supendi and Prihatmanto (2015), so the determination of which psychological aspects that are evaluated in a selection process can be carried out within a scenario based on game mechanics is still open for discussion.

The most relevant aspects on which deep reflection can be carried out are related to the presentation of the test in a selection process, and in that order of ideas, the time factor of the application of the test stands out. It is presented as an advantage with this game model while reducing, between 40% and 70%, the time records. These data have as a reference Albadán Romero *et al.* (2016), where it is argued that a psychological test, within a selection process, takes about an hour. This comparison is made considering the

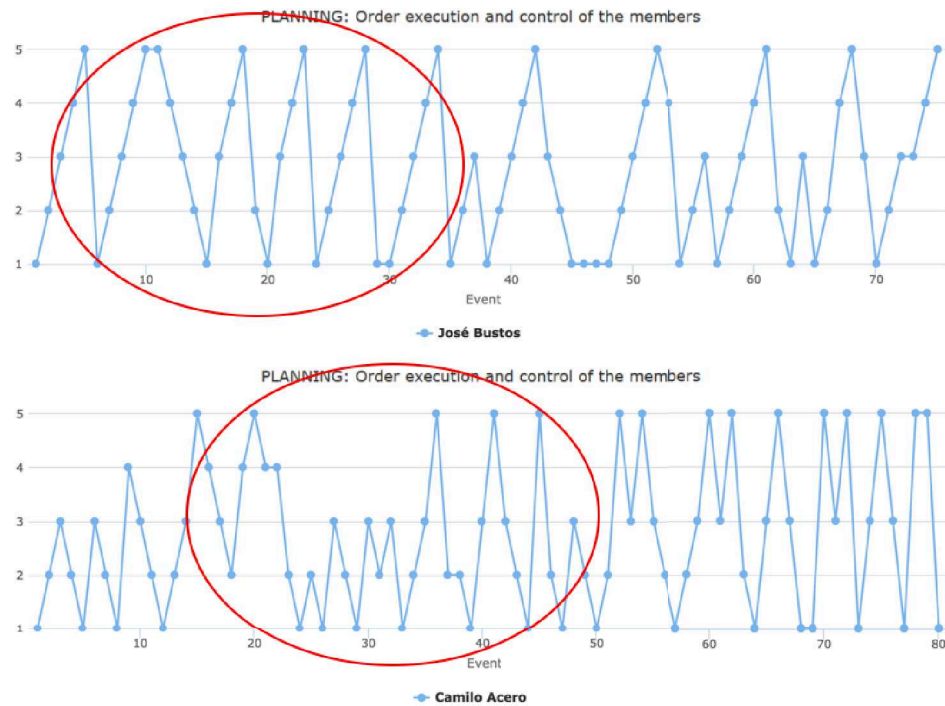


Fig. 4. Points sequence curve denoting an applicant's planning competence.

duration records of the proposed game. The advantage affects the two parties involved in the selection process: the applicants and the organization.

Based on the results obtained, models based on rules of inference can be applied to consolidate the profile of an applicant. However, there are variables associated with psychological competencies that require a more detailed analysis from strategies that allow for the analysis of the behaviours of an aspirant when making certain decisions. To this end, it is suggested to apply tests by implementing methodologies based on eye tracking, as supported by Bobić and Graovac (2016), with which it is possible to capture subjective aspects such as facial expressions or vision, from more specific tests, as detailed in Ujbanyi *et al.* (2016) and Zhang and Chen (2016).

7. Conclusions

The design of a test model based on gamification was carried out with the inclusion of different organizational and psychological theories. These characteristics allow one to obtain the characteristics of the behaviour of the aspirant while playing and even use them to complement the scenario of self-evaluation, facilitating the processing of those aspects without the player even being aware that it is being analysed.

In that order of ideas, there is a great advantage to obtaining such data, in terms of consolidating the profile information in the background. So, we have grounds to affirm

that the data capture works in an optimal way when implementing game mechanics, while allowing the implicit transfer of information.

Although certain decision-making strategies have been linked directly to the connotation of non-programmed decision-making, it is evident that the large amount of data generated after interaction in the game does not make it easier to determine if the applicant made a decision using a pessimistic approach, an optimistic approach, or other criteria, considering that in many cases, this can be a product of rapid actions within the dynamics of the same game, beyond reaching to contemplate and analyse all the possibilities of choice to make use of the criterion.

Considering that we designed randomly generated events, which appear unexpectedly, and that it is not possible to know how many times and at what moment something specific happens, or if a fight is won or lost, it is considered that there was adequate work done to delimit the characteristic of non-programmed to the decision-making. On the other hand, the psychological competencies consolidated in the reports were chosen from a list of psychological abilities associated with the decision-making processes, with which considerable statistical details about the profile of the aspirant are considered.

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