Maturity in decision-making: a method to measure e-participation systems in virtual communities

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Abstract: The participation of citizens in the decision-making of a community is the essence of a democracy. As the number of citizens grew, direct participation became utopia and delegated to elected representatives. The spread of internet allied to the population pressure for transparency in government's decisions brought mass participation back to the table. The communication channels are there, though citizens' participations have not been effective frequently because their suggestions are not mature. This paper presents a method, maturity in decision-making (MDM), for measuring the maturity of a group for a decision considering the risk of group-thinking, shallow analysis or even polarisation. We have applied the method in two scenarios with promising results.

Keywords: web-based interaction; web measurements; social networks; e-government; decision-making; virtual community.

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1 Introduction

There are many governmental decisions for which citizens should and could participate to achieve the public good. Brazilian elections, plebiscite and referendum are examples of society participation in the country directions. On the other hand, these mechanisms are still shallow participation since people are faced with predefined options to choose from. Internet has brought a wide range of possibilities to foster public participation in the government decision-making. A wide range of applications, software and tools are available to support the implementation of electronic democratic processes (Garcia et al., 2005; Maciel et al., 2016; Tambouris et al., 2007). In this research, we are particularly interested in tools that foment a richer kind of citizens' participation, such as: online surveys and web applications (Kavanaugh et al., 2007). Although powerful, web virtual communities have interactions and offer communication resources not necessarily focusing on citizens' deliberative decision-making process.

The deliberative decision-making process of a group can be a result of argumentative discussion, sourcing and evaluating options, and voting, mediated by technology. Nevertheless, whenever citizens are asked to participate in public processes, they individually receive information from different media of communication, make sense of it individually or in small groups, form their opinion and vote. This process is condemned to be bias and conducted by the stronger voice in the media. Additionally, since forming an opinion is a mental and inner process, it is quite impossible to verify the citizens'

opinion maturity before voting. Consequently, the question concerning the actual citizenship role of the individual in the society's directions remains.

In order to investigate such problem, the government-citizen interactive model (Maciel and Garcia, 2007b) was proposed, so as to support the maturity in decision-making (MDM) method. In this research, two distinct experiments simulating the structured deliberative process (Rowe and Frewer, 2000), which includes consulting the population for alternative solutions and voting, are analysed in order to measure the maturity of the population for decisions taken through two different scenarios: the application of online surveys and the use of a web application, the 'democratic citizenship community' (DCC).

The null hypothesis (H_0) of this study considers that there is no difference in measuring maturity levels in either methods, online surveys or virtual communities, regarding decision making using method Y = f (DMM) in e-democratic processes. In the alternate hypothesis (H_1), it is defined that method Y = f (DMM) allows measuring maturity level in an agile and integrated way regarding decision making in e-democratic processes by means of a virtual community.

The need to measure the degree of maturity by online surveys and by a virtual community (the DCC) is due to the impossibility of comparing the citizens' maturity for decisions to other virtual communities, as there are not integrated debating and voting processes in them.

Web applications offered by social networks, such as Facebook, are environments of intensive participation and interaction among members, thus being an important channel for the government to come closer to citizens. Nevertheless, apart from being used for entertainment and marketing, such applications have their discussion structure based on a post or picture, so it is difficult to organise information per demand (or topic in discussion). Besides, discussions are spread in different spots on the social network. Argumentative web environments, such as offered by deliberatorium (Klein, 2011) offer a structured environment for fostering and discussing ideas based on posts classified as issues, ideas and arguments pro and against. However, they impose people an extra work of classifying their posts.

This paper is structured as follows. After the introduction, in Section 2, the government-citizen interactive model is briefly presented. In Section 3, the method for measuring decision-making is proposed. The case study and analyses of these experiments according to the MDM method are presented in Section 4. Section 5 shows the hypothesis test and in Section 6 the correlated works are discussed. Finally, the last section includes conclusions and bibliographic references.

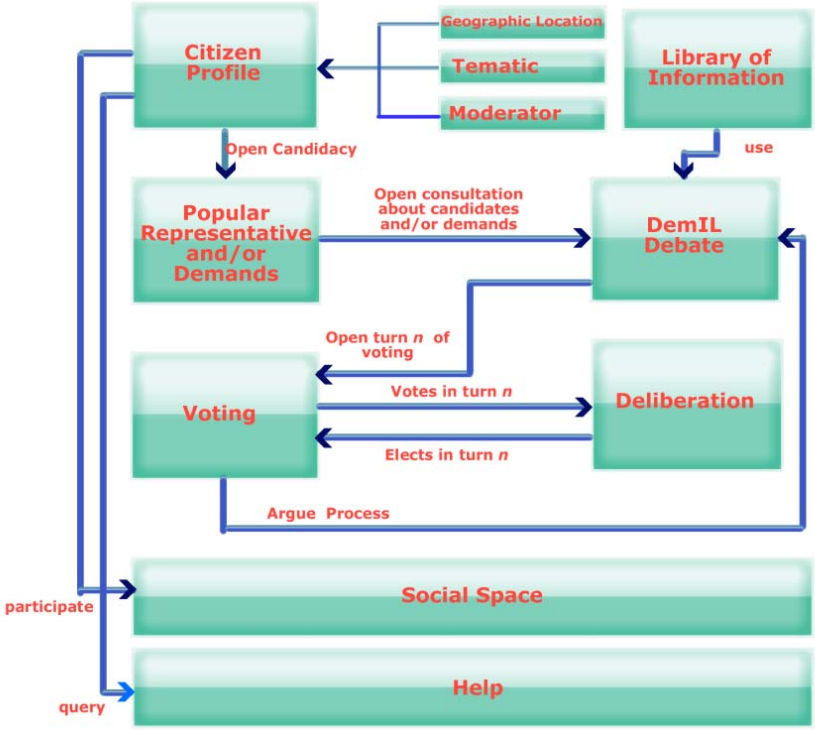
2 A model for citizens' e-participation

It has been a worldwide effort to bridge the gap between citizens and government. Although the effort, citizens have remained aside in government decision-making. Garcia et al. (2005) presented a list of major flaws in e-government sites that prevented citizens to properly access information and to contribute to government decisions. On the other hand, few sites that overcame the interaction barrier also failed to gather citizens' participation due to inabilities to conduct fruitful discussions. The interactive government-citizen model (Maciel and Garcia, 2007b) was proposed to foster citizens

discussions over government issues to reach a set of advises that reflect the public opinion concerning what the government should do in a specific circumstance. Figure 1 illustrates the proposed model. The main characteristics of this model are:

- the construction of a community with similar interests
- a logical debate structure that organises and labels citizens' contributions to make easier to search and understand the debate
- the definition of a special player in the debate: the moderator
- a voting system to allow a conclusion to be reached.

Figure 1 Interactive government-citizen model (see online version for colours)



Source: Maciel and Garcia (2007a), Maciel et al. (2011, 2016)

In order to test our ideas, we built a debate tool called DEMIL (Maciel and Garcia, 2006) in which participants could register to use it, therefore there was no anonymous participation. Registered participants could join or create a discussion topic. Participants could log into DEMIL just to socialise with the group DEMIL. In this case, contributions are posted as in a forum. The idea here is that at first people want to know who is there. Participants could also check the active debates and decide to join in some of them. In this case, the participant needs to select a label for his contribution as well as to decide to which existing information in the debate his contribution should be appended. Each debate has a moderator that is responsible to maintain consistency within the debate. He checks whether participants are properly labelling and locating their contribution as well

as trigger people to better explain a post. The moderator is also responsible for calling a vote or finishing a debate. Moderators are selected by votes. They need to apply for the role and the group elect them.

Although DEMIL demonstrated the potential use the interactive government-citizen model, the tests indicated some limitations that may prevent the adoption of the model, mainly its lack of features to address accessibility, privacy and security issues and its dependency to one specific type of debate closure (votes). It is common to have different types of popular consultation including referendum, focus group and consensual closures.

DEMIL debate structure, the social actor-network theory (Latour, 1999) and the dynamics of groups in virtual communities (Maciel, 2008) created the foundation for our current research. We also considered the evaluation metrics of the software engineering (ISO/IEC 9126-3, 2003) area to apply in our research.

Choudhury and Sundaram (2011) investigated the factors that influenced individual participation in conversations on social networks. For the authors, discussions generated from content posted by users are crucial for studying user experience. As characteristics of the impact on conversations and debates on social media, their study indicated that debates fostered the formation of communities and the development of shared media. Additionally, they noted the debate environment nurtured creative thinking. The authors commented that frequently new topics were raised from user's comments to original contributions.

Nov et al. (2014) discussed the implications of citizens' different motivations when developing technology-mediated social participation. They developed an experimental study in which citizens participated in science projects using their framework considering four different motivational factors: collective motives, norm-oriented motives, intrinsic rewards, and reputation. From the experiment, they inferred a set of design guidelines for citizens' participation in online e-science projects, such as, norm-oriented interaction foster higher quality citizens' contributions. They also identified interesting impact on the results from demographic aspects, such as, age had a significant negative effect, indicating that younger people tend to contribute more frequently, while gender and computer expertise had insignificant effects (except for the significant positive effect of participants' expertise in one particular setting).

In a survey that analysed the political interests of German youths, Spaiser (2011) identified that they were interested in using the Internet for political reasons, although they felt frustrated that politicians did not answer their questions neither responding nor participating in online debates. Bringing people to participate requires human and computer power to respond to them. This is one of the current challenges of implementing systems to bridge the gap between citizens and government. Beyond the technical challenges there is also the human acceptance barrier. People, especially old people, still prefer to have an offline interaction with other people and the government.

Kavanaugh et al. (2007) investigated the impact of personal affiliation to local groups and political participation on the Internet. The study concluded that as the Internet use becomes more widespread, voluntary participation in groups tends to grow as well as the level of communication and active participation in these groups, especially in civil-political groups. Their findings also show that being a part of the online local groups also promote face-to-face interactions, such as meetings, community activities, meetings with friends and voluntary work, especially among opinion leaders.

Similarly, Conroy et al. (2012) have shown that online political groups produce similar effects to traditional off-line groups, especially in terms of their ability to foster political engagement. By providing the means of easily creating online political communities, they argue that social networks, such as, Facebook, are encouraging deeper political engagement. Thus, it is necessary to ensure, as in the real world, that all deliberations are done in a aware and mature way.

3 Maturity in the decision-making method

The maturity of a group is the composition of the individuals' ability to contribute to a process (technical skills) and to behave accordingly to what is expected when performing certain tasks. The expected behaviour demonstrates the degree of individual

1 commitment to accomplish the task

2 responsibility with the outcomes

3 leadership over a group

4 collaboration with others to accomplish the task

5 work organisational abilities, among others.

Therefore, the maturity of a group is defined by the predominance maturity of the individual composing the group. Measuring the maturity of a group is important to define the quality of the decisions made by the group. This section presents a method for measuring the maturity of a group formed to discuss and assist the decision-making over certain issues. Therefore, we are focus on deliberation tasks.

For Simon (1965), the decision-making process is a matter of choosing among options that lead to actions. Therefore, creative brainstorming to draw options, critical analysis of the options and rational selection are required steps towards a fruitful decision-making process. When accounting for citizens' participation, this process requires technology to take place, characterising e-participation. This online setting lays the environment in which we will be able to measure the degree of maturity of a group using the MDM method.

The five steps of the MDM method include:

1 The definition of the debate purpose: it is important that both the government and citizens have a social purpose, a public interest, as well as a concern with deliberating on the proposed issues.

2 The definition of the concluding method: There must be a public manifestation, such as a referendum on a certain topic (Rowe and Frewer, 2000), so that people can discuss about their decision-making.

3 The definition of the debate *modus operandi*: setting a deliberative process in stages is fundamental, as it is proposed in the model.

4 The definition of the evaluation instruments: instruments that were structured according to the process must be employed to collect data from citizens. For this study, we propose online surveys and a Web application that was projected for such purpose.

5 The definition of the debate time set for collecting citizen's participation: in order to make the participative process effective, the data must be collected from the interested public within a previously set (in stage 2) start date and deadline.

After collecting all data, the individual and the group maturity are measured as a function of fours indicators:

- Int_Part – Are everybody registered? Are there candidates for filling the moderator role? (number of people registered to participate compared with people browsing the debate (RC), and the number of candidacies for being a moderator (CM).
- Part_Discussion – it clusters information of the discussion such as the number of topics posted in the debate (QPD), the number of valid arguments posted in the discussion by topic either agreeing, disagreeing or neutral (QPOV), the number of interventions of the moderator suggesting his performance as moderator (AM), the number of visits, just browsing activity, in posted participations(VCD).
- Part_Decision – it cluster information involving the number of votes (PV) and the number of justification for votes (JV).
- Part_Social – it cluster information involving the participation in the socialisation space: by posting news (PN), inviting friends (CA) and/or accessing other members' profiles (APM); using the information library to post links (PL) and/or post documents (PD); as well as the number of invalid justifications posted in the discussion (negative point) (-QPOI), identified by the moderator, not automatically.

Table 1 presents the points scored according to the MDM scores by indicator. The counting process of the data is uniform, and for each task executed in the MDM method a certain score is attributed. The final score is achieved by weighted sum of the points. Each indicator has a weight that is used to normalise the final score. For example, for the Int_Part indicator, 1 point is attributed when a user registers (RC) and another point is added if she applies to be a moderator of, at least, one topic (CM). Then, if the user participates in these two events, he will get two points (Int_Part = RC + CM). The weight of this indicator equals 10. Some indicators have score limits. For example, for up to three post views, the user gets one point; from 4 to 10 post views, he or she gets two points; for more than ten post views, he or she gets three points.

Each indicator has its own weight, as showed in Table 1, which was defined considering that:

a showing interest in participating is the basic request to take part in the process, so that its weight is low (10)

b participating in the debate is important for members to discuss the demands, improving their opinions, thus it is weighted on 30

c participating in the final decision, that is, voting on the debated demand, represents the deliberation itself, so it is highly weighted on 40

d socially participating in the environment, which indicates how much the member interacted in the community, is weighted on 20.

These weights are assigned based on our intuition and on previous pilot studies for getting a final score. However, we believe they need to be fine-tuned and may depend on the importance of the topic.

The score of the indicators and the attribute weights should be adapted to the complexity of the e-deliberative process. Through the application of the MDM method, it will also be possible to statistically refine the scores and adjust the metrics.

Table 1 MDM scores

Indicator	*Variable*	*Scores*	*Score limit*	*Weight*
Int_Part	RC	1pt.	2	10
	CM	1pt.		
Part_Discussion	QPD	1 pt. by demand	10	30
	QPOV (F, C, N)	1 to 3 posts = 1 pt. 4 to 10 posts = 2 pts. More than 10 posts = 3 pts.	[5 + QPD (up to 5 pts)]	
	AM	If moderates discussion = 1 pt.		
	VCD	1 pt. by view		
Part_Decision	PV	1 pt.	2	40
	JV	1 pt.		
Part_Social	PN	1 pt. by news	10	20
	CA	1 pt. by invitation		
	APM	1 to 3 accesses = 1 pt. 4 to 10 accesses = 2 pts. More than 10 accesses = 3 pts.		
	PL	1 pt. by link		
	PD	1 pt. by document		
	-QPOI	–1 pt. by invalid opinion		

Finally, the e-participation maturity classification is defined as (Maciel and Garcia, 2007b; Maciel, 2008):

- Immature: there is an interest in participating in the discussion either as a contributor or as a moderator, however without commitment to the results or to check the consequences of the debate. It seems that participation is more for curiosity tan for making a change. Most individuals tend to abandon the process.
- Poorly mature: there is an interest in participating in the discussion either as a contributor or as a moderator. Most individuals participate either in the discussion phase or in the voting phase, but not in both.
- Mature: there is an interest in participating in the discussion either as a contributor or as a moderator. Individuals remain until the end of the debate process participating in the conclusion. Most individuals participate in both the discussion and in the conclusion/voting phases.

- Socially mature: there is an interest in participating in the discussion either as a contributor or as a moderator. Individuals remain until the end of the debate process participating in the final conclusion. Most individuals participate in both the discussion and in the conclusion/voting phases. Additionally, individuals follow the results of the decisions in real life and keep the community alive by updating with the actions follow-up.

The degree of maturity can be useful for measuring both citizens and the government involved in a participatory decision-making process. As time goes by, citizens can understand how the method works and thus try to improve their degree of maturity. Therefore, the degree of maturity must be visible to the user, which could involve a reputation system. Besides permitting a deliberative process via web, the method also enables the government to quantitatively evaluate the decision-making process on questions of public interest and to qualitatively analyse citizens' opinions and interests.

4 Case study

This section presents the results of two experiments to analyse the feasibility of using MDM to measure the maturity of groups in a debate environment. We used online surveys by stages, and a web application, the 'DCC' as basis for our experiments.

In both experiments, the subjects were voluntary computer science students of two different universities, the Fluminense Federal University, in Brazil, and the University of Coimbra, in Portugal. We asked all volunteers to sign a consent form that made them aware of our research objectives and how we would use the collected data. They were invited by email and informed that they could leave the experiment whenever they wanted.

4.1 The online survey case study

This section explores the first experiment, carried out with online surveys.

4.1.1 Method

The methodology suggested to measure a structured deliberative process explores the application of online surveys by stages (Maciel and Garcia, 2007a). Users were invited by e-mail to participate voluntarily in the study. The first available survey was designed to collect general information from the interested participants and to make a public consultation on the matters to be later discussed. In the second survey, individual opinions were shared and discussed. In the third survey, all themes and referred opinions were structured and made available so that participants could take a stance on a form of voting. This stage also included a user satisfaction survey. In the end, the deliberation report was generated.

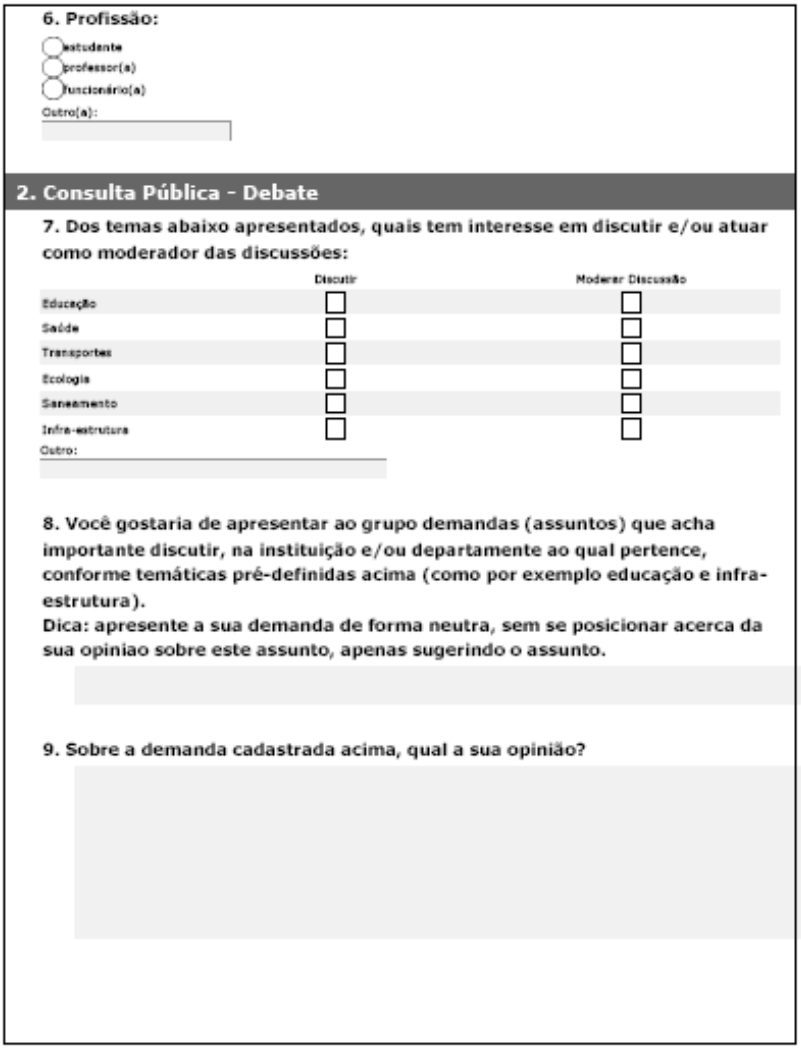
4.1.2 Subject

From the 100 students randomly selected and invited by email to participate, 27 of them volunteered to answer the survey. Their average age was 33 years old, ranging from the minimum of 23 to the maximum of 48 years old. Participants were mostly male students.

4.1.3 Task

Participants have to answer three online surveys, specified by Maciel (2008), as exemplified in Figure 2. Surveys contained about 15 questions each. All three surveys had to be completed and sent within 30 days. Up to two email notifications were sent to remind participants to answer the surveys. After the experiment, a user satisfaction survey was also sent to them (Maciel, 2008).

Figure 2 Survey online



4.1.4 Collected data and MDM evaluation

The maturity level points were assigned according to the MDM model. Individual and group maturity were calculated. Table 2 presents the group evaluation as a function of the individual evaluation. As illustrated, there are 13 people classified as immature and only three as socially mature.

4.1.5 Analysis

Out of the 27 participants of the consultative and deliberative process, 13 were classified as with 'immature' participation, because they abandon the discussion. The 'mature' level of participation was achieved by nine of the participants, who participated from the very beginning of the process, by registering demands, debating, voting, and evaluating the process as a whole.

Table 2 MDM online survey groups

Maturity	*Range*	*Qty*
Immature	from 1 to 28 points	13
Poorly mature	from 29 to 57 points	4
Mature	from 58 to 86 points	9
Socially mature	from 87 to 115 points	3

Three users were classified in the 'socially mature' category because they keep asking for the actions implemented even after the experiment was completed. It demonstrated they were actually involved in the process.

The presence of contradictory opinions favoured the discussion, but surveys demonstrated an inadequate instrument for debate since the discussions are not openly posted. Therefore, the right to offer a rebuttal becomes restricted and many additional steps in the surveys became necessary in order to sustain a more vivid discussion. The asynchronous interaction aspect of the survey tool also restricted the moderator action. Other important issue concerned the registration of demands that had to remain open during the consultative stage, so that participants may suggest new subjects for discussions at any moment.

Each participant's self-assessment was also requested regarding his participation in the consultative and deliberative process. 23.1% considered their participation 'very good', 46.2% considered it 'good' and 30.8% considered it 'regular'. It must be added that this self-assessment was requested from respondents who participated in the final stage of the process, consequently it can be analysed compared to the indicators generated by MDM. The users who participated in the final step (voting) were mostly classified in groups 3 and 4, which only confirms the positive self-assessment, since they participated in the process actively.

In our experiment the maturity indicator was calculated manually, however the experiment demonstrated the feasibility f the approach. The results are not satisfactory, due to the limitations of the surveys.

4.2 The DCC case study

This section presents a second experiment, using DCC.

4.2.1 Method

Considering the government-citizen interactive model, a 'public consultative committee' manifestation was registered and a schedule was defined for the process (Maciel et al., 2010). For the use of the DCC, we considered the following phases:

1 registration of the participants

2 registration of the participants' demands

3 debate of opinions regarding the demands

4 voting

5 user satisfaction survey

6 deliberation of results.

During the initial contact between the user and the DCC, he had the opportunity to register his interest in acting as a moderator. After users register demands, moderators were elected and assigned by the administrator. Before enrolling, users must read the terms of use and electronically sign the consent form.

The schedule for the entire process was restricted to 20 days. The 'invitation to participate' in the experiment was sent by e-mail, through the lists of the institutions involved in the research. During the deliberative process, automatic warnings were sent to participants concerning deadlines.

4.2.2 Subject

76 of them volunteered to participle in DCC. The average age was 30 years old, ranging from the minimum of 25 to the maximum of 53 years old. They were all male computer science students.

4.2.3 Task

Participants interact with a argumentation system, called DCC, designed to allow large groups to interact over a topic.

The system is available at the address http://www.comunidadecdc.com.br/ (a system in Portuguese). After registering or logging in the DCC webpage, the user is directed to adjust his profile, as illustrated in Figure 3.

The DCC has interaction and communication resources, accessible by links in a tool bar, such as citizens' profiles, debate (demands registration and discussion), voting, information library, socialisation space and user's help. The system administrator has distinct functions, accessed in the option «administration» in the tool bar.

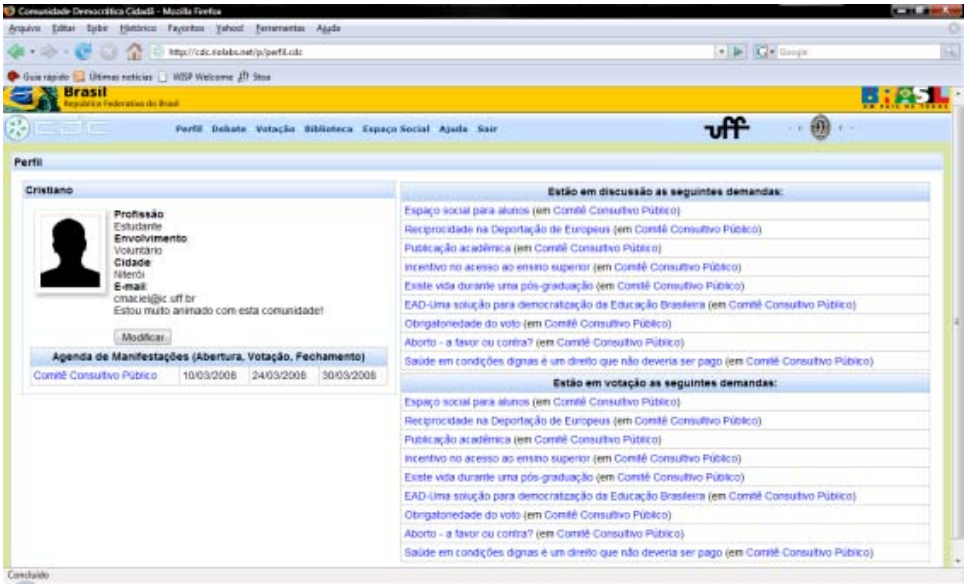
In both «debate» and «voting», demands are listed and divided into themes and it is possible to participate in them in the previously scheduled period. The moderator responds to the opinions in debate by means of specific types of interference (Maciel et al., 2009). After the discussion period, when the voting process is opened, the citizen selects an option as his final vote, in the «VOTING» link.

For the citizen to obtain information there is a «digital library» with web links. In the «socialisation space», the citizen visualises other members' profiles, sends invitations to potential new members, publishes pieces of news in a board or simply visualises this

board. The DCC also has a «Help» menu to clarify users' doubts about using the environment.

Participants were expected to join one or more of the open discussions, contribute and help the group reach a conclusion.

Figure 3 Citizen's profile (see online version for colours)



4.2.4 Data analysis

After implementing and, consequently, managing the DCC in a practical case, the data were analysed by means of usage statistics, with the aid of the analysis of log registers in the administrator's view, Google Analytics tool and with a user satisfaction survey in the end of the process. The complete analyses about this experiment were published in (Maciel et al., 2010).

The MDM scores over the DCC group discussion were automatically calculated. The moderator had a special view of the discussion as illustrated in Figure 4.

Table 3 presents the groups classification, according to the MDM.

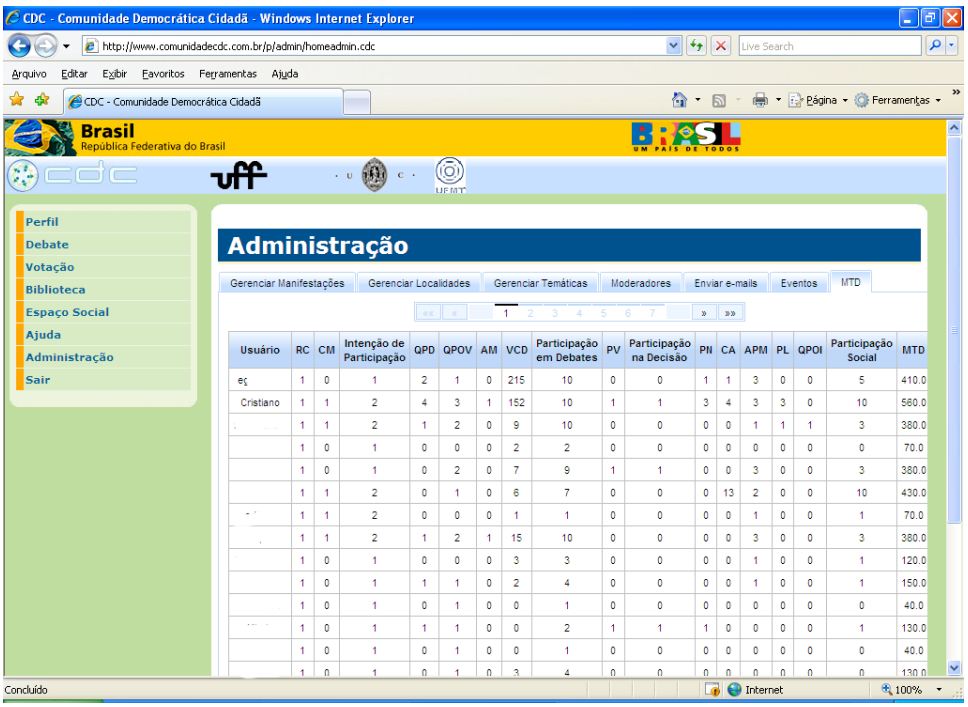
Table 3 MDM DCC groups classification

Groups	*Range*	*Qty*
Immature	from 1 to 16 points	46
Poorly mature	from 17 to 33 points	3
Mature	from 34 to 50 points	20
Socially mature	from 51 to 66 points	3

Based on the analysis in the previously presented table, it is possible to see that 46 users had an 'immature' participation in the e-deliberative process, since they showed initial

interest in participating, but abandon the experiment in an early stage. Such users basically registered and took a look at the environment.

Figure 4 DCC – MDM data (see online version for colours)



Usuário	RC	CM	Intenção de Participação	QPD	QPOV	AM	VCD	Participação em Debates	PV	Participação na Decisão	PN	CA	APM	PL	QPOI	Participação Social	MTD
eç	1	0	1	2	1	0	215	10	0	0	1	1	3	0	0	5	410.0
Cristiano	1	1	2	4	3	1	152	10	1	1	3	4	3	3	0	10	560.0
	1	1	2	1	2	0	9	10	0	0	0	0	1	1	1	3	380.0
	1	0	1	0	0	0	2	2	0	0	0	0	0	0	0	0	70.0
	1	0	1	0	2	0	7	9	1	1	0	0	3	0	0	3	380.0
	1	1	2	0	1	0	6	7	0	0	0	13	2	0	0	10	430.0
	1	1	2	0	0	0	1	1	0	0	0	0	1	0	0	1	70.0
	1	1	2	1	2	1	15	10	0	0	0	0	3	0	0	3	380.0
	1	0	1	0	0	0	3	3	0	0	0	0	1	0	0	1	120.0
	1	0	1	1	1	0	2	4	0	0	0	0	1	0	0	1	150.0
	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	40.0
	1	0	1	1	1	0	0	2	1	1	1	0	0	0	0	1	130.0
	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	40.0
	1	0	1	0	1	0	3	4	0	0	0	0	0	0	0	0	130.0

In group 2, there were only three users, who either debated or voted, not taking part in both steps of the process. It is believed that those who debated, but did not vote have done so due to alleged personal problem that prevented them from returning to vote during till the deadline.

'Mature' participation, in the e-deliberative process, was identified in 20 users. Only three people reached the 'socially mature' classification. In these cases, classifying a user either into the 'mature' or the 'socially mature' group considered if the member had registered on any demand in the discussion, acted as a moderator or sent invitations to friends. In these groups, all users participated in the voting stage. During the debate stage, not all members actively contributed by posting opinions, but they showed interest in the process by reading other members' posts and by using other virtual environment spaces, though acting as active members in the DCC discussion tool. Thus, this study also shows the dividing line between these groups is fuzzy and needs tuning.

During self-assessment phase, 30 DCC users answered the survey. 10% of the members considered their participation 'excellent'; 30%, 'very good'; 36.7%, 'good'; and 23.3%, 'regular'. 23 users considered their participation to be satisfactory, which confirms the results from the MDM method: at least 20 users were classified in the 'mature' group.

5 Hypothesis test

The hypothesis test indicated for the present experiment makes it possible to compare statistics of two independent samples of numeric data that are extracted from two distinct, normally distributed populations (Maciel, 2008). In this case, the samples include individual maturity index (DMM), measured by experiments through online survey and through DCC.

The pooled variance of student test t is used to determine the difference between the mean averages of both populations (Effing et al., 2011). For this purpose, 25 DMM-level samples were selected from each population to calculate the pooled variance of test t, with the use of simple random sampling.

This study's hypothesis test asks if the mean average (μ) of DMM points is the same when using the survey and when using a virtual community for an e-deliberative process. In order to answer this question, the null and alternate hypotheses are:

H_0 $\mu 1 = \mu 2$

H_1 $\mu 1 \neq \mu 2$

The rule for the decision is:

Reject H_0, if $t > t48 = +2.0106347$

or if $t < -t48 = -2.0106347$

else, do not reject H_0.

Based on the data, it is possible to calculate the value of t, as presented in Table 4.

Table 4 Test for the hypotheses

Calculation for test t		
Hypothesis of difference	0	
Level of significance	0.05	
Population sample 1	*Survey*	*DCC*
Sample size	25	25
Sample average	42.44	24.08
Sample standard deviation	39.46737	19.663672
Liberty levels of pop.1 and of pop.2 sample	24	
Total liberty levels	48	
Pooled variance	972.16667	
Difference in sample averages	18.36	
Test t statistics	2.0818878	
Test bicaudal		
Inferior critical value	–2.0106347	
Superior critical value	2.0106347	
Value-p	0.042708	

For this experiment, value t is equal to 3.4520158. Using the significance level 0.05, the null hypothesis (H_0) is rejected, since t = + 3.4520158 > t48 = +2.0106347. The probability of significance or value-p is equal to 0.042708. In other words, the probability that t > 3.4520158 or that t < –3.4520158 equals 0.042708 (intermediate calculations for t). Because value –p is less than $\alpha = 0.05$, there is enough evidence to reject the null hypothesis.

Therefore, it can be concluded that the average measurements of the DMM method are different for the use of surveys and of the DCC. Based on these results and on the qualitative and quantitative analyses, the DMM method measurements seem to be better suited for the virtual community DCC.

For this reason, this study accepts the alternate hypothesis (H_1), which states that the method Y = f (DMM) can measure the maturity level concerning decision-making in e-democratic processes swiftly and in an integrated manner, by means of a virtual community.

In this sense, it is worth noting that, since counting DMM points is an automatic process by means of the DCC, computing the maturity level becomes swift. Because a decision-making process involves a group of people deliberating on various matters, the use of integration resources and the communication involved may make it harder to compute the maturity level, due to the complexity of updating information from system use. However, due to the integrated environment in which the process is occurring, as well as the automatic counting of DMM points within the system, it is possible to swiftly generate the DMM degree.

There are also benefits with the integration of important resources in the environment, such as the availability of information in a library, and the possibility of socialisation, thus allowing individuals to feel responsible for the shared ideas and acquire confidence based on the mutual relationship established in the environment. One must also consider how easy inserting new resources in the integrated environment becomes and, consequently, in the DMM method, facilitating adaptability to both.

6 Related works

With the advent of virtual communities, merely structural analyses can be important, but in this area it is crucial to take the social structure and the content of the virtual community into consideration. Thus Ho et al. (2000) investigated how long users remained in a virtual community, and the kind and amount of activities they took part in. They classified users in three groups: one with generally positive attitudes, another one with generally negative attitudes and a third one with inexperienced users, with generally neutral attitudes. In another research, Butler (2001) identified three categories of participants, which he called leaders, active and silent users. A possible classification of users who adopt technology in a certain period of time, discussed by Rogers (1995), divides them in the following groups: innovators, early adopters, early majority, late majority and laggards. Moore (1999) proposed a similar classification in which users are classified into technology enthusiasts, visionaries, pragmatists, conservatives and skeptics. Although the classification criteria are different, the idea is quite similar among researchers. The ability to engage in social media, to adopt a new technology to perform usual tasks is key to successful e-citizen participation tool. The e-environment should not only foster fruitful discussion, but also break the ice in making people adopt the

technology. Often the group may abandon the discussion prevented by the technology itself.

Adiele's research (Adiele, 2007) on measuring group maturity is similar to what we have proposed with MDM method. Adiele presents a formal framework for dynamically measuring participants' interactivity degree within a community. Interactivity refers to number of active contribution and the relevance of contributions, according to the community's needs. Relevance is inferred through the community acceptance over participants' contributions (posting a 'like' for instance). Members' performance is measured in accordance with their contribution to the community, through what is called activities. The members were classified in the following groups (Adiele, 2007):

a leading members are those who make substantial contributions to the community by posts, often reading and answering messages

b active members are those who make any contribution to the community, but in a smaller quantity than the leading members

c non-active members are those who make minimal contributions, if any, to the community.

When it comes to a community aimed at deliberative processes, non-active members can vote, even if they do not take part in the discussions. Therefore, non-active members, observers, can influence the final result.

Distel and Becker (2017) claim citizens' familiarities in forums and their perception of the quality of the e-government services define their willingness to provide civic participation. They also stress the needs for mediation to assess the group discussion maturity.

According to Effing et al. (2011), previous efforts to configure public participation using Internet tools have not achieved successful results. It is difficult to define and measure e-participation. Seeing the potential offered by social media to political parties and non-profit organisations, Effing et al. (2011) put forward questions for future research, such as: what are the main design principles for optimised implementation of social media as an instrument of participation in non-profit organisations with traditional communities? The model proposed in this research helps to answer such questions since some of these principals are described in Maciel et al. (2016).

Our research helps to shed a light on establishing a method to measure the maturity in a deliberative process supported by a virtual community, by classifying users' participation as immature, poorly mature and mature or socially mature.

7 Final considerations

The integration of consultative and deliberative environments for popular participation in democratic matters and the creating of virtual communities makes it possible to model decision-making processes. As described in this paper, this particular study derives from the organisational perspective of decision-making (Simon, 1978) and from the maturity types (Maciel, 2008). Based on public participation methods (Rowe and Frewer, 2000) and creation of virtual communities (Maciel, 2008; Maciel et al., 2011), this paper presented the following contributions:

- The generation of an original participative model, the Government-Citizen Interactive Model, which makes it possible to structure a consultative and deliberative process on the web, supported by virtual communities, which allows users to exercise their citizenship and permits transparency in governmental agencies' actions;
- The MDM method, which makes it possible to measure the participation of individuals in deliberative groups through a set of indicators; and
- A differentiated approach to modelling and evaluating virtual communities, presenting a metric for measuring the effectiveness of individual participation in a process that swiftly integrates discussion and voting in an integrated form.

The challenges faced our research concerned a method to measure the maturity of individuals and groups in the decision-making process. Due to being an original application, there are no other researches for comparison. Making adaptations in the proposed model will allow new experiments to be developed that might refine the method. It is believed that the method, as well as the proposed model, can be adapted by institutional purposes of other countries, which are interested in democratic deliberative processes.

This method can be adapted to other domains, not necessarily public, but that conjugates the opinion of many into a common interest. Therefore, MDM method indicators should be analysed to define which indicators would be useful for different applications. Also, the developed model considered the features of a consultative and deliberative process in which people socialise through virtual communities. From this model, the components can be extracted and adapted to other applications, especially social networks. For instance, if a system does not require voting, the 'vote component' can be left out.

It is important to point out that technologies must be faced in e-democracy as means, not ends. They should not be regarded as neutral, because they carry values, concepts, social views, conflicts, privileges and excluding processes. Technologies were created to solve concrete problems, thus having political and social content. By themselves, they cannot warrant citizens' active and critical participation in public interest issues. Success in a consultation and voting process is not directly related to the employed means, that is, technology, but to citizens' and government's motivation and interest in making it possible.

The MDM was assessed based on members' participation according to the kind of manifestation, in this case a 'public consultative committee', with specific interests. If the analysis of the MDM is carried out by demand, it is seen that there is a substantial change in the degree of maturity ascribed to the users, considering their particular interests in certain discussions. On the other hand, to make sure whether there would be changes in the members' degrees of maturity, it is necessary to submit the same group to a manifestation of the 'public consultative committee' type, in order to check their maturing in relation to their decisions. Therefore, new experiments are possible and they can improve the method.

The experiments permitted to check the proposed model and method of this research, but it is evident that, when creating a fictitious community, not managed by the government, some issues simply do not apply. Other serious challenges are posed in the search for e-democracy, since the use of such system by millions of citizens (e.g., in a

national discussion) highly increases the complexity of the model. Influential groups, such as, activist politicians' hackers or lurkers, can use the MDM method as a front end to influence the opinion of others. Reputation system should be coupled to any argumentation tool to record and reveal participants' bias, when presenting information and the voting.

When it comes to members' participation in the community, a greater effort must be made towards stimulating users with a weaker participation in the process, those with lower MDM degrees, to participate in the debates and consequently in the voting process. We are now working on the development of a model to stimulate participation, based on recommendations to comments and on users' reputation according to their MDM history. We also intend to audit information posted in social networks and VCs, such as CDC.

Maturity models measure the quality of a process to reach a solution. There are maturity models for measuring the quality of e-government data and services, but there are no models to measure the quality of a crowd in an e-democracy context. MDM is the first one and can serve as a starting point. Nonetheless, there are a set of metrics that can be perceived as useful to compare with future results including: generalisability, degree of automation ability, anomaly detection ability, understandability and usefulness. Generalisability indicates the degree of applicability of the model to specific crowd interaction settings. For instance, the model may only be applicable in a voting phase. Degree of automation ability reflects who will make inferences from the model: the computer or a human agent. Anomaly detection ability refers to information to detect anomalies in the decision process such as group thinking (Rosen, 2011). Understandability refers to clarity of the model representation for a human reasoner. Finally, the usefulness metric refers to the degree of support the outcome provides to assist decision-making. An initial evaluation of MDM leads to Table 5.

Table 5 MDM evaluation

	MDM
Generalisability	High (any phase or task)
degree of automation ability	Human inference
anomaly detection ability	Semi-automatic
Understandability	High
Usefulness	High

We have postulated the indicators and the thresholds to define the maturity classification. As future work, we will investigate the use of data mining techniques, specifically association rules (Agrawal and Srikant, 1994; Liu et al., 2015), over the 14 variables to tune our heuristics. For doing so, we will need to gather a significant set of labelled cases of group participation on decision scenarios. We plan to start in a controlled environment such as within a University context. Labelling participants' contributions and involvement will be a challenge and a validity threat. The benefit of using a data mining technique will be to minimise bias included by human heuristics.

Additionally, as future work, we will investigate the applicability of fuzzy logic to calculate the MDM indicators to comply with the subjectivity of the metrics. We need more case examples to adjust and refine the boundaries and the pertinence function for each indicator.

Finally, it is important to say that the proposed method to measure the degree of MDM can be employed in distinct deliberative processes and in other kinds of virtual communities, as long as the participation indicators are adapted to the purposes of the application.

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This paper is a revised and extended version of our previous work published in Maciel and Garcia (2007) and Maciel et al. (2009, 2010, 2011). We updated the related work, explained the method for measuring the maturity in decision-making method and, more importantly, included the empirical study confirming the feasibility and accuracy of the method.

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