Evaluation of E-Participation Efficiency with Biodiversity Measures - the Case of the Digital Agenda Vienna

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Abstract: *We introduce the Effective Number of Issues measure for e-participation efficiency. This novel index is based on the Shannon entropy measure of biodiversity and summarizes the amount of information gained through an e-participation project in one number. This makes the comparison between different e-participation projects straightforward and lays the foundation for the rigorous analysis of success factors of e-participation projects in a data-driven way. After providing the formula and rationale for the new measure we use the ENI index to benchmark the idea generation process for the digital agenda Vienna against other projects. It turns out that the efficiency of this project is significantly higher than those observed for other cases. We conjecture that this can be attributed to the user-friendly design of the software platform and the effective communication strategy of the process management. Finally, suggestions for further research are given.*

Keywords: *E-Participation, Evaluation, Shannon Entropy, Biodiversity, Digital Agenda*

1. Evaluation of E-Participation

Evaluation is essential for learning and improvement. Therefore, evaluation has been an important part of many large-scale e-participation projects. To aid managers and sponsors of e-participation projects in evaluating their effort, multi-level frameworks for e-participation evaluation have been developed by Macintosh and Whyte (2008), Aichholzer and Westholm (2009) and Simon et.al. (2011). Parycek et.al. (2014), for instance, build on this basis and evaluate the political, technical, social and methodological levels of their OurSpace project with a variety of methods. While providing a complete picture of the effects of an e-participation project these approaches have the drawback that cross project comparisons are difficult due to the variety of measures and scales employed. Thus, cross sectional studies to derive success factors for e-participation done so far had to rely on interpretation rather than on data-driven methods for deriving their conclusions (see Kubicek et.al. (2011) and Panopoulou et.al., 2010). More rigour would be possible if there was a standard measure of e-participation success, which could be related to project characteristics to estimate impact factors in a quantitative way. A first step in this direction is described in Taudes and Leo (2014). They apply econometric methods to a set of

document based e-consultations to derive estimates for the number of votes and comments to expect from this technique.

In this work we describe a novel measure for e-participation efficiency based on a biodiversity measure that summarizes in one number the amount of information content gained in a consultation or participation project. In this way we want to contribute to the further development of e-participation by laying the foundation for the collection of consistent evaluation data which will enable rigorous analysis of success factors in a data-driven way. We will provide the formula and rationale for the new measure in section 2. In section 3 we will apply the measure to the idea generation process for the digital agenda Vienna e-participation project and compare this process with other e-participation projects. Finally, we will indicate some extensions of our work in section 4.

2. Measuring the Efficiency of E-Participation

2.1 An Information Flow View of E-Participation Efficiency

"e-Participation … can be defined as the exploitation of ICT for engaging citizens to participate as much as possible in democratic procedures, interacting among them, as well as with politicians and decision makers and providing them with the necessary information and appropriate rights in a way that reinforces their role in the decision making process" (Ergazakis et.al., 2011). Thus, an important goal underlying both e-participation and its cousins, the related fields of public consultation, community engagement and stakeholder engagement, is to generate a flow of information from the participants to the sponsor. In respect of the evaluation of projects in these fields it is helpful to distinguish between two aspects: effectiveness and efficiency. We can define effectiveness as the extent to which the participation changes what the sponsor does, or plans to do, or thinks. We can define efficiency as the extent of the information flow from participants to sponsor (Rowe and Frewer, 2005). Having defined efficiency as an information flow, the problem then is how to measure that flow of information. One of us (May, a) has proposed that the information which flows in a consultation or participation project consists of the issues which it brings out.

It turns out that theoretical ecology offers very useful analogies for the evaluation of participation (May, a). Two ecological concepts are highly relevant, namely 'community' and 'diversity' – terms which have very particular meanings in ecology. Ecologists have been dealing with communities of species inhabiting a particular location, and the diversity of those communities, for many years and they have developed theoretical approaches which we can make use of.

If we regard the outputs of a participation project as a 'community of issues' then we can apply some of the insights of community ecology to the evaluation of e-participation (and to the other members of the family as mentioned above). We begin with the idea that island communities originate by migration from a mainland. We can think of the mainland as being populated by the full range of issues relating to the topic of our participation project. We can also think of different islands as being different participation projects. We also assume that we cannot access the mainland directly, and the only communities available to us are on the islands. This is a reasonable assumption to make because if we already had full knowledge of all the issues we would not need

to carry out participation projects to find out what they were. Thus island populations consist of issues that have migrated from the mainland, so that the greater the number of issues we find on a given island, the greater the flow from the mainland. Since we have defined efficiency as the extent of this flow it follows that the more efficient participation or engagement projects will produce a greater flow of issues related to the topic of interest.

2.2 The ENI Measure

The next question is then how to measure this flow. The natural-seeming way to do so is simply to count how many different issues there are in the community – the "issue richness" by analogy with the ecologists' "species richness". Thus we might conduct a participation project in which the community consists of 10 issues – one of them mentioned 91 times, and the others once each. The issue richness is 10. Another project on the same topic (a different island) might also produce a community of 10 issues, but each one mentioned 10 times: once again the issue richness is 10. Although the richness is the same in both instances the flows from mainland to island are clearly not identical. The two frequency distributions are very different, with one being very unevenly distributed while the other example is completely even. What is needed is a measure that takes into account both the number of issues and also their even-ness.

Ecologists use a variety of measures to take in to account both the richness of a population and its even-ness. Technically what is being measured is the diversity of the population and the different measures are diversity indices. One such index is the Shannon entropy. In its raw form this index is not terribly enlightening: in the two examples given above the Shannon entropies are 0.50 and 2.30 respectively, whose meanings are not exactly transparent. The importance of the Shannon entropy for our present purpose is that it is relatively easy to transform it in to a quantity known to ecologists as the 'effective number of species'[1]. Much has been written about the effective number of species as a measure of ecological diversity and the interested reader is referred to Jost's paper (Jost, 2006).

May (a) has proposed using this measure, renaming it the 'effective number of issues' or ENI, for the flow of issues in participation and engagement projects[2]. In the two examples given above the ENIs are 1.65 and 10.00 respectively. It is at this point that the value of the ENI becomes clear, because we can now compare the efficiency of these two projects simply by dividing the larger ENI by the smaller. Doing this shows the second project to be approximately 6 times as efficient as the first (10.00/1.65). We are not aware that this degree of precision in estimating the efficiency of a participation project has been possible before.

Calculating the ENI is relatively straightforward so long as one has a list of the issues raised during the project and the number of times each issue was raised – the frequency distribution in other words. The first step is to calculate the Shannon entropy of the distribution, which involves working out the relative frequency p_x of each issue x, taking the natural logarithm of each relative

[1]The formal definition of effective number of species is the number of species which, if equally represented in the population, would have the same diversity index as the one actually observed. The effective number is generally less than the observed number and cannot exceed it.

[2]There are precedents for borrowing a concept from one discipline and applying it to another. Physicists, economists and information scientists for example all use a version of the effective number of species (Jost, 2006, p.363), and in fact one can trace its intellectual pedigree back to the birth of the science of thermodynamics. Shannon used the letter H in his entropy formula because of its close similarity to Ludwig Boltzmann's H-theorem which played a significant part in the development of thermodynamics.

frequency, then multiplying the logarithm by the relative frequency and summing the results. Multiplying this sum by negative 1 gives the Shannon entropy (conventionally written as H'). The second and final step is then simply to raise the number 'e' to the power of the Shannon entropy, for which the formula is exp H'. This gives the Effective Number of Issues, and hence a precise and rigorous measure of the efficiency of an e-participation project.

$$\text{ENI: } \exp(H'),\ H' = -\sum p_x \ln(p_x). \qquad (1)$$

Readers who are not familiar with algebra, but who have a basic knowledge of Excel, might like to look at the step by step guide given in May (2013). In addition there are a couple of calculators which will do the first step. Danoff-Burg and Xu (2005) have written an on-line calculator. Download the Biodiversity Calculator from this site, enter the list of issues in the first column of the main sheet and their frequencies in the second. The Shannon Index is calculated automatically and is shown in the pale green box labelled Shannon H'[3]. The University of Reading (n.d.) has produced a 'Diversity Add-in' for Excel which calculates the Shannon Index. Download the Diversity Add-in from the site, install the add-in and select 'Shannon' from the add-ins menu. Then input the list of frequencies and the Shannon Index is calculated automatically. Step two, converting the Shannon index into the ENI is achieved by using the 'exp' function in Excel.

Since Shannon entropy is a key concept in information theory we could have gone straight to the information content of the flow from participants to sponsor by calculating the Shannon entropy of that flow. However, we believe that the biodiversity route using the mainland/island, community richness and community even-ness analogies is more intuitive, despite being more roundabout. We also suspect that theoretical ecology has more analogies to offer to the understanding of participation. Do communities of issues evolve over time, for instance? And how do we account for a distinctive pattern of issue abundances which has been observed on several occasions? Questions for another time.

One interpretation of the Shannon entropy is that it represents uncertainty. If we pick one participation issue at random, how certainly can we predict what it will be? In a maximally diverse population with each issue having the same frequency each type of issue is equally likely to be selected if we make a random choice; thus our uncertainty as to the identity of the random choice is at its greatest, the corresponding entropy is at its highest, and the ENI is equal to the observed number of issues. In a less diverse population there is less uncertainty: our random choice is more likely to produce one of the most abundant issues than one of the least abundant ones; the corresponding entropy will be lower, and so will the ENI.

The ENI has a theoretical minimum value, but no theoretical maximum. The minimum is 1, as is found in a single-issue referendum. (We note in passing that this makes the recent Scottish independence referendum the least efficient way to ascertain Scottish views on the subject. But of course the debates before, during and after the referendum itself did convey a great deal of information.) There is no theoretical maximum, but based on (unpublished) analysis of 70 consultations from 36 case studies, involving a variety of consultation/participation methods and drawn from four different countries, we suspect that in practice values above 150 will be rare.

[3]This calculator also contains much else which need not detain us here.

3. Idea Generation for the Digital Agenda Vienna

Let us now demonstrate the use of the ENI index by comparing its value for the digital agenda Vienna (DAW) with other projects described in May (b) and May (c). DAW aims to develop Vienna's requirements for information and communication technology from different angles (citizens, business, employees, etc.). Five questions are to be answered to achieve this goal:

1. How should the future ICT infrastructure of the City of Vienna be designed?
2. How can Vienna as a business location be further developed by ICT?
3. How can the City of Vienna use ICT to support her residents and businesses better in all circumstances?
4. How does ICT change government in the future?
5. What concerns arise from an increasing digitization of the Vienna City government?

Answers are sought for the following areas of activity of the Vienna city government: ICT and the workplace of the future; information, communication and participation including social media, infrastructure and technology; ICT in the growing city; ICT and mobility; E-Government, the networked society (connectivity), security, safety and privacy; ICT and Vienna as a business location; ICT and inclusion; and eHealth and ICT in the social sector with regard to health, social policy and an aging society.

The DAW process was intentionally designed to strongly involve citizens in the deliberations and decisions on the future course of the City of Vienna with respect to the digitisation of the economy, administration and society. Of course, and this was made clear, the final decisions on controversial issues would remain in the hands of the Vienna city government.

The DAW project was set-up as a 3-step process based on an idealised strategy formulation process: ideation -> organising of ideas and document drafting -> validation of arguments contained in the document. Phase 1 took place from September, 1st, 2014 to October, 18th, 2014. In phase 1 participation was open to everyone and the citizens were asked to upload their ideas to www.digitaleagenda.wien. The platform detailed the intention, explained the process, and provided background information (see Figure 1). The process was actively managed by Community-based Innovation Systems GmbH (cbased) which was also responsible for moderating the process and encouraging citizens to participate. The latter was done jointly with the City of Vienna using existing channels. The encouragement of citizens to participate benefitted from the very active involvement of the City government in the ideation process and in reporting on both the process and the progress made.

On www.digitaleagenda.wien the users could not only upload their ideas and assign them to one of the above mentioned five categories; they could also express agreement or disagreement by voting and commenting on the ideas (see Figure 2). This stimulated discussion, helped highlight controversies, and identified those ideas that attracted most support. The structure of the content was not prescribed in any other way, so that the participants were free to describe their ideas in their own words.

Special attention was paid to the information given to the participants about the project's purpose and process. A compromise between ease of understanding and completeness was struck by showing an overview on top of the page and including links to downloadable background documents which gave detailed insights into the process, its purpose and the institutions involved.

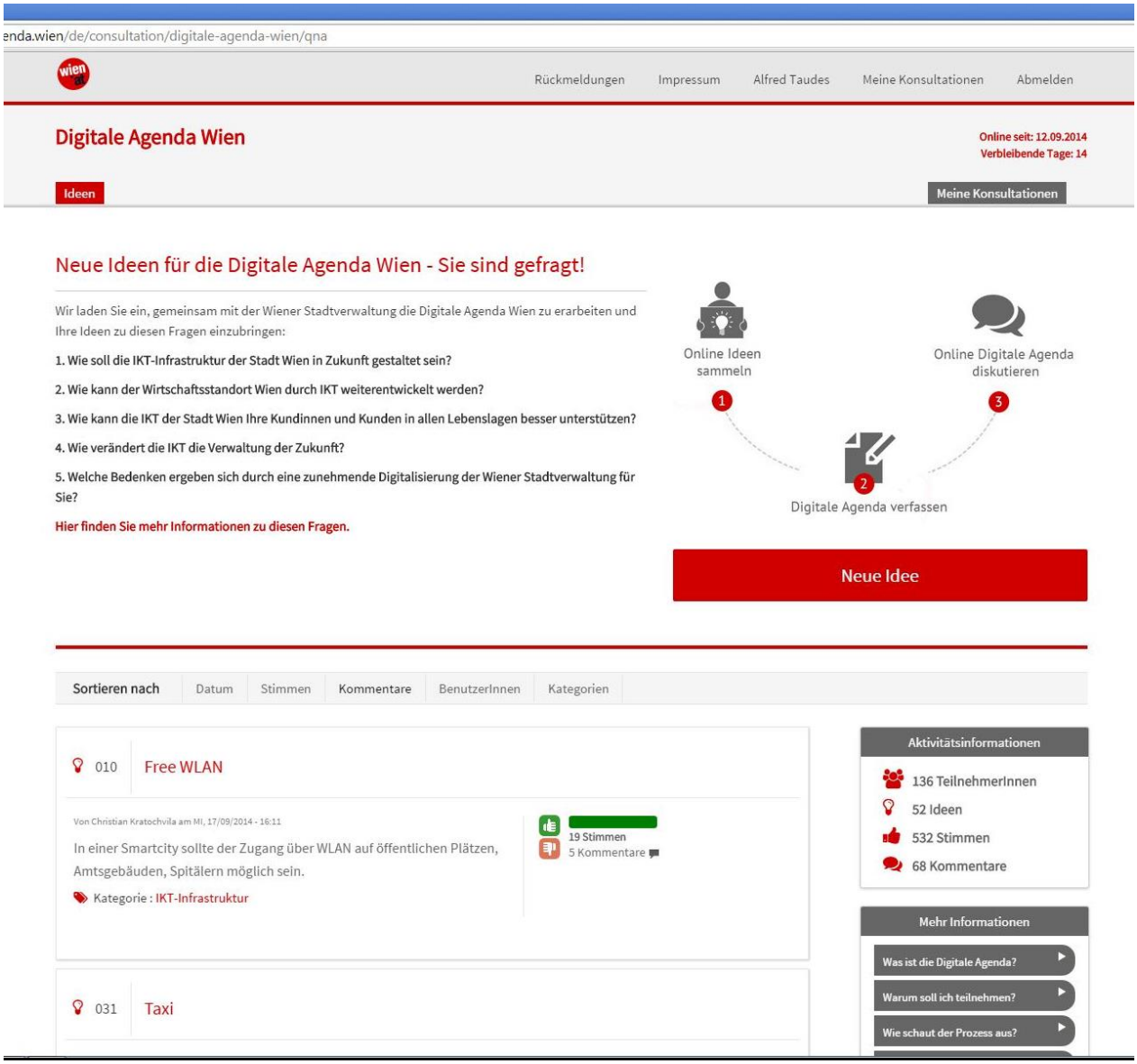

Figure 1: Start page of www.digitaleagenda.wien

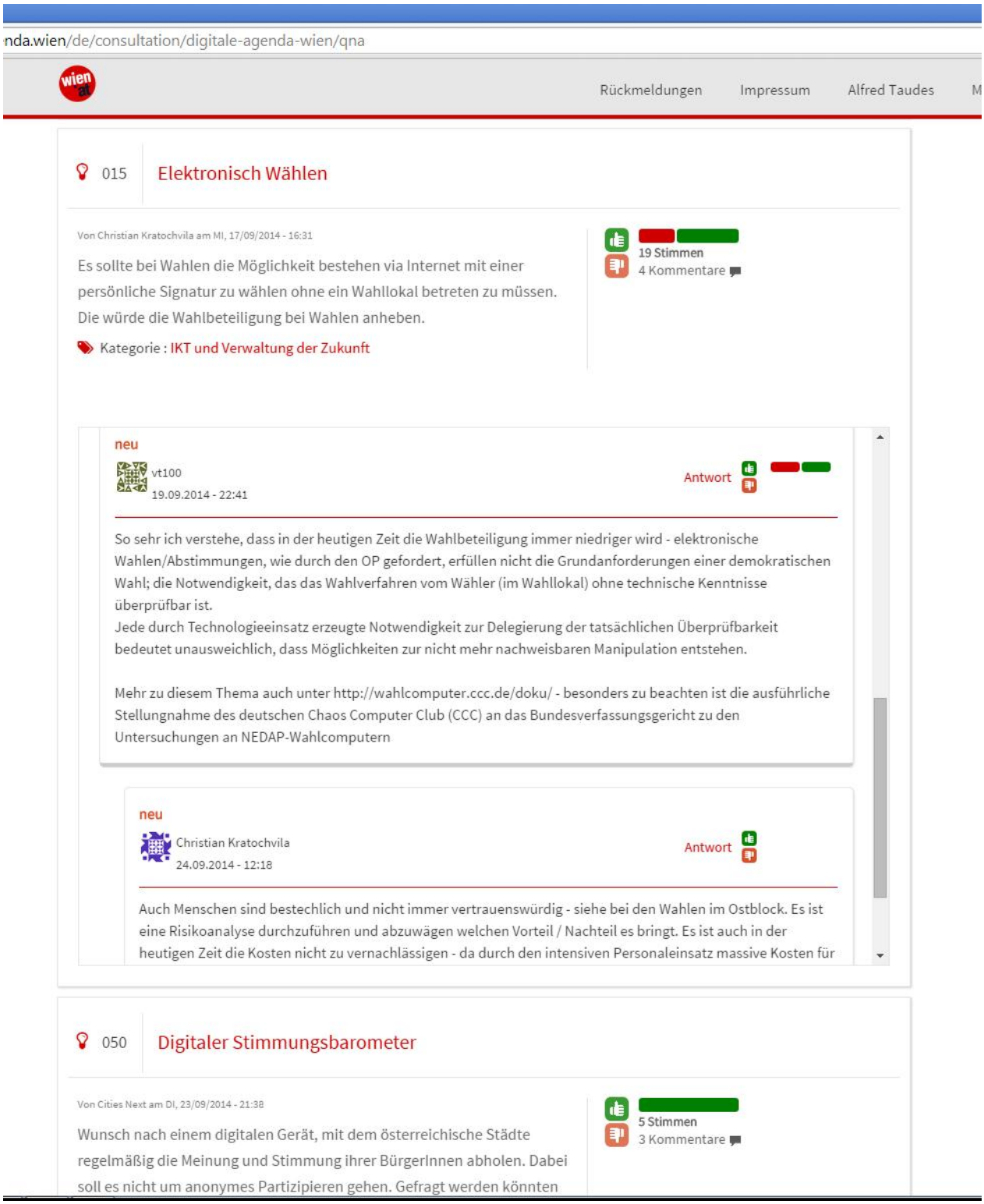

Figure 2: Discussion of an idea on www.digitaleagenda.wien

At the time of the writing of the article, the process was in phase 2. Phase 2 is a traditional offline strategy process in which working groups combine the ideas created in the first phase with the expertise of invited experts coming from academia, ICT vendors and consultancies. The working groups correspond largely to the five questions at the start of this section and are led by external experts and Vienna city government team members.

In phase 3 the draft version of the DAW will be discussed online. The draft agenda will be automatically split up into paragraphs by the cbased software and participants can vote and comment on these paragraph, in much the same way as happened in phase 1. Again, the voting on paragraphs quickly reveals controversial issues and - via comments - potential ways to improve the arguments laid out in the paragraph.

This "anchoring" effect is induced by the design of the cbased platform which openly displays the results of the voting. This is a highly efficient way to focus discussion on the controversial issues. At the same time it is important to pay attention to contributions that don´t raise controversies but may contain substantial potential for improvement or innovative approaches, solutions, etc. Independent assessment - i.e. without paying attention to the inputs of other users through votes and comments - remains a necessary ingredient for getting the most out of the content generated by participants.

At the time of writing this article, the first online phase has been completed and the offline phase is under way. It is expected that the third phase will be completed by the beginning of March 2015, leaving some time to introduce changes based on the discussion and to seek approval from politicians. The whole process will last for about 7 months which is extremely fast for strategy processes in the public sector. Indeed, the effect of particpation has been to speed the process up rather than slowing it down. A precondition of such an agile process is support by the politicians in charge of the issue as well as by the City government. Actual responsibility for the process and execution was with the CIO of the City and her team which worked in close cooperation with cbased, Computer Sciences Corporation (CSC) and a number of external experts. cbased was responsible for the design of the process and the programming, implementation and management of online elements. CSC took care of the offline process while a number of experts managed and contributed to the working groups.

Table 1: Excerpt of ENI calculation for the DAW data set

Idea	**Text**	**Votes**	**p_x**	**$p_x \ln(p_x)$**
1	Elektronische Services für alle Lebenssituationen anbieten	15	0,00612	-0,03119
3	Amtswege per Mouseklick übers Internet von zu Hause erledigen können	25	0,0102	-0,04677
8	IT-Security-Awareness-Initiative in den Wiener Bildungseinrichtungen starten.	16	0,006528	-0,03285
…	…	…	…	…
Sum	Sum of $p_x \ln(p_x)$			-4,98
exp H'	where $H' = -\sum p_x \ln(p_x)$			145,9

An essential element was the continuous involvement of citizens. They not only contributed in the online processes but were also invited to join the working groups. More than 20 people took up

this invitation. There was also a continuous flow of information on ongoing events so that participants had the necessary details to follow progress.

The public idea generation in the DAW project yielded 171 ideas/issues and 2.451 votes and 296 comments from 372 participants. An excerpt of the dataset used is given in Table 1, the complete set is publicly available at https://open.wien.at/site/wiener-geistesblitze/. The ENI index value resulting from the DAW data is 145.9. To put this in context, May gives a number of examples which have ENI's ranging from 1.7 to 65.6 (May, b). An unpublished analysis (May, c) of 12 months' worth of posts to an on-line neighbourhood forum found an ENI of 85.0[4]. So the DAW project ENI of 145.9 holds the record at the time of writing. What could be reasons for this success? May (b) empirically validates on the basis of 15 cases that the efficiency of a consultation is determined largely by the degree of control which the sponsor imposes on the exercise, and also by the 'capacity' of the participants to respond. In the DAW case the degree of control was minimal, in that the question was open-ended and participants could say anything they wanted to (so long as it was on topic and not offensive). Also, participation was not mandatory. Capacity refers to the capacity the participants have for responding to the particular topic. The DAW respondents were all, or mostly, people with detailed knowledge of and great interest in the subject and thus 'high capacity'. In addition the project managers made significant efforts to increase capacity through the provision of relevant information.

4. Possible Extensions and Future Research

While it is still early days, it does appear that the ENI technique can be applied to just about any participation/consultation/engagement method which generates a frequency distribution of issues relating to the topic being investigated. The technique was first developed for open-ended question formats, such as the DAW, where participants are invited to say anything they want so long as it is relevant and not offensive. In these formats the issues list generates itself, while the frequency can be taken as the number of votes for an issue, the number of "Likes" it attracts, the number of posts on an issue, the number of times posts are re-tweeted, etc.

However, the ENI can be extended to closed questions of the Agree/Disagree (Likert scale), multiple choice or ranking varieties as well. In the open-ended case it is the distribution of the responses to each open ended question that is used, and not the content of the responses – not even whether they were basically for or against a proposition. The same principle applies to closed questions: it is not the degree of agreement or the ranking assigned that matters, just the number of times each option was responded to in any valid way. Thus we exclude "No reply", "Don't Know" and indifferent (Neither/nor) responses from the frequencies. Some may argue that by ignoring the 'flavour' of the responses the ENI wastes valuable data. We believe the benefits of obtaining a consistent measure of efficiency outweigh the losses, and of course the detail of the responses is still available for further analysis after the ENI has been calculated.

As a means to the end of an informed democracy we believe the ENI has a lot to offer. Now that we have a method for measuring efficiency in a consistent manner across participation projects the

[4] The dynamic nature of on-line forums means that it is important to record the date on which the ENI is measured and to specify the period. In this case starting the 12 month period just 4 days later would have increased the ENI to 89.9.

way is open for practitioners and academics to explore such questions as "what makes one consultation or participation project more efficient than another?" and thus to build up a knowledge base which can improve all our practice. A necessary condition for this endeavour is the availability of data on e-participation projects. To foster this research, the City of Vienna has decided to publish the ideas generated on www.digitaleagenda.wien as open data in Vienna´s open data portal at https://open.wien.at/site/wiener-geistesblitze/. We hope that other sponsors of e-participation projects will follow suit.

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