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# Practice of Design Science Research in a Developing Country: Circumscription Knowledge Informed by the Socio-cultural Context in India

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## **Abstract**

Technology-mediated participatory systems facilitate collaborative effort by citizens, enhancing the opportunities to address large-scale problems such as those arising out of climate change. Following a design science research (DSR) methodology, we present and instantiate a design framework in a developing country, India. Results from instantiation and analysis of participant interviews reveal a critical aspect to the practice of DSR: in contexts with minimal circumscription knowledge, meta-requirements informing the design can be extracted not only from kernel theories, but also be revealed from investigating their fit to the local context. This study expands the domain of research in information systems (IS) by addressing a novel theme - the provision of information and communication technology (ICT) resources for community collaboration and highlighting the innovation for its design based on socio-cultural context. We also extend ICT for development by illustrating how the reconstitution of IS innovation within the context occurs: locally understood and negotiated socio-cultural mores interacting with ICT, giving rise to an 'emergent' culture.

**Keywords** design science research, mobile, public participation, developing countries

## 1 INTRODUCTION

Most nations around the world are currently impacted by challenges arising out of climate change and environmental degradation. Recognising the need for a concerted effort by citizens to solve these large-scale problems (Reed 2008), governments in developed nations have begun supporting technological systems to enable such participatory collaboration. The use of technology-mediated public participation systems in developed countries has shown that it enhances opportunities for finding solutions (McLavery 2017). Unfortunately, while participatory systems to address challenges have proliferated in the developed countries, their uptake is severely lacking in developing nations where the need is most critical (Preece & Schneiderman 2009) leading to a further loss of opportunities. Citing the increased burden due to the new challenges on developing countries, information systems (IS) researchers have urged the research community to design IS to help gather, assess and analyse relevant data to enable governments to formulate appropriate policies (Malhotra et al. 2013).

This urgent need for IS solutions and the dearth of systems capable of ensuring participatory approach in addressing current concerns motivated us to explore the development of such a design. The widespread use of mobile devices in developing countries (Thakur & Srivastava 2014) suggests that a mobile technology based solution can facilitate universal citizen participation in addressing problems. The inadequacy of extant participatory system design in enabling optimal public participation in developing nations has motivated us to explore this domain. Consequently, in this paper, after presenting the research background (section 2), we explore the barriers to implementing extant system design in developing nations' context, in this instance, India, and identify the research questions to be investigated. In section 3, we explicate the design science research methodology (Peppers et al. 2007) followed by this research. In section 4, we draw upon the knowledge base of existing theories to extract design requirements, infer design principles and present the design prototype. In section 5, we detail the demonstration of the design prototype in the field (Guntur District, India) and present an evaluation and an analysis of the underlying conceptual principles conducted using focus group interviews and structured interviews via case study method (Yin 2009; Pries-Heje et al. 2008; Peppers et al. 2012). The findings from the study fall along a socio-cultural dimension, an information and communications technology (ICT) dimension and a socio-economic dimension. Findings pertaining to the socio-economic dimension are discussed in another paper (forthcoming) and delineate the impact of macro-level regulatory policies on the mobile ecosystem and their influence on individual mobile use behavior at the micro-level. In this paper, the focus is on the first two dimensions and we show how the meta-requirements for the design framework are revised based on the analysis of the interview data. Finally, we conclude by highlighting how our research extends work in DSR in IS by highlighting the role of circumscription knowledge in the development of design and suggest future research.

## 2 RESEARCH BACKGROUND

The design of technology-mediated participatory systems has evolved along two streams – a social science theory-driven design stream (Kraut et al. 2012) and a more functional 'problem-solving lens' stream. The social science theory-driven design is known as evidence-based design. It uses social science theories that predict the antecedents necessary to invoke participation and contribution to the social movement to govern the design flow. Literature is rich with descriptions of such theories and their design rules (Kraut & Resnick 2011; Arazy & Gellatly 2012). Social science theories predict the required motivations to be aroused in order to complete participation and contribution. A multitude of research has clarified the design features instrumental in invoking the various motivations and their impact on participation rates (Mason & Watts 2010; Ling et al. 2005; Nov, Arazy & Anderson 2011). The 'problem-solving lens' stream is focused on understanding and clarifying system design given the technological constraints of participants' devices. In this stream, design requirements are guided by 'problem-solving within the context' and utilise the characteristics of the device to invoke motivations that may lead to participation and contribution. The 'context' is typically a resource poor community wherein design must adapt to the affordances of existing technology devices. Since a majority of resource poor communities have access to one common communication device - a mobile telephone device - they have been the de-facto artifact on whose technical affordances, the participatory design is structured (Jun and Hui 2010; Hellström and Karefelt 2012; Schneider and von Briel 2013).

Since extant participatory systems already exist, a translation of the design to a developing nation context ought to be straightforward. However, there are a few problems. First, a review of literature highlights factors unique to a developing country context such as low levels of literacy, lack of ICT skills, high data costs (Robinson & Imran 2015). Second, extant design of participatory systems has organically evolved in the context of devices with higher motivational affordance (Zhang 2008) capabilities. Lastly,

participation occurs when either the participants are aware of issues and thus motivated to participate, or, there are minimal barriers to participation (Klandermans & Roggeband 2007). Public participation systems in developed countries are designed for commonly used devices thus eliminating many barriers to accessing the system. Given the lack of information on the level of awareness and hence, of motivation, to participate for common good in a developing country context, the only recourse is to ensure barriers to participation are removed. For a technology-mediated participation system to succeed, it is crucial that members of the community participate (Nov et al. 2014). However, literature search has not revealed a design framework that ensures optimal participation through overcoming barriers for a public participation system specifically for common good.

## 2.1 Research Questions

Thus constraints to translating extant design to the developing country context characterized by low levels of literacy, lack of ICT skills, device variation and data costs inspire our first research question (RQ1): What are the underlying design principles for a technology-mediated participatory system for the common good in this context? It is recognised that people participate in movements because they feel rewarded for their effort (Schroer & Hertel 2009), so, we aim to study this with our second research question (RQ2): How can one implement the motivating factors into the design framework?

## 3 RESEARCH METHODOLOGY

This research question is addressing the utility of a design artifact, so, the research question enumerates the research method - design science research (DSR) - where design is a method (and not a topic) of investigation (Livari 2015) and given the research question, is explanatory. Literature (Walls et al. 1992; Livari 2000; Hevner et al. 2004; Gregor and Jones 2007) defines design science research as a problem-solving approach that results in the creation of innovative artifacts that address unsolved problems or address them more effectively. These new artifacts are its constitutive and distinctive research outputs. The current research has identified the lack of technology-mediated participatory systems in the context of a developing country and intends to intervene in the 'real world' by designing an IT meta-artifact as a general solution concept that is later instantiated as a specific solution for the environment, thus, subscribing to the first strategy of conducting DSR (Livari 2015). Design science research methodology is a six-stage process (Peppers et al. 2007) with rigour incorporated into each stage starting from problem identification and design to presentation and evaluation. Peppers et al. (2007) mental model for presenting and evaluating design science research in IS is based on a synthesis of processes as proposed by Walls et al. (1994) and Hevner et al. (2004). It consists of a set of six activities or elements in a nominal sequence as follows: Activity 1 consists of problem identification and motivation (Introduction and Research Background sections of this paper). Activities 2 and 3 consist of delineating the objectives of a solution and extracting meta-requirements from kernel theories (section 4). Activities 4 and 5 consist of demonstration and evaluation/discussion (sections 5 and 6). The last activity involves communicating the outcome of research (this paper).

## 4 OBJECTIVES OF A SOLUTION AND META-REQUIREMENTS OF DESIGN

Based on an analysis of the shortcomings in translating extant design to current context, and of the contextual conditions, we stipulate the objectives of a potential solution (Robinson & Imran 2015): Enable optimal participation in a system for common good, support diversity of accessing devices, ensure removal of barriers to participation and lastly, facilitate fulfilment of motivational needs.

### 4.1.1 Meta-requirements (MR) delineated from the objective 'Enable optimal participation in a system for common good'

Since the design has to enable optimal participation, we endeavor to reduce barriers to participation and hence, assess the theories that delineate conditions that will lead to optimal participation for common good. Rowe and Frewer (2005), 'evaluate' various participatory mechanisms and suggest the normative theory for public participation (Webler 1995) as prescribing the most 'effective' or 'optimal' participatory process. Webler's normative theory of public participation is a revision of concepts of the ideal speech situation (Habermas 1979) and the theory of communicative action (Habermas & Habermas 1985). It argues that 'fairness' and the 'competence/efficiency' of the participatory mechanism in achieving its intended purpose are the necessary conditions under which public participation, at least in the domain of environmental decision making, is made possible. Fairness refers to the opportunity for all interested or affected parties to assume any legitimate role in the decision-making process. It is operationalised as

the ability to attend (be present), initiate discourse (make statements) and participate in the discussion and decision making (Webler & Tuler 2001). Competence refers to the ability of the process to reach the best decision possible given what was reasonably knowable under the conditions. It is operationalised as access to information and to its interpretations and the use of the best available procedures for knowledge selection (Webler & Tuler 2001). Thus, from the objective 'Enable optimal participation in the participatory system' the meta-design requirements extracted are: MR 1. Provision of access to and engagement with moderators and other participants; MR 2. Monitoring of context for provision of necessary knowledge and expertise MR 3. Provision of procedures to take part in decision making in the context of available knowledge.

#### **4.1.2 Meta-requirements (MR) delineated from the objective 'Support diversity of devices'**

The mobile ecosystem is highly fragmented and multiple devices with varying degrees of affordances are used (Basole & Karla 2011). Any design that enables universal access needs to ensure that all participants can get in touch with moderator or other participants and access information in any format facilitated by their device affordances. Therefore, the design must ensure that access and provision of knowledge are compatible with the most common affordances and capabilities of mobile devices (Shneiderman, 2000; Jaarvenpaa & Lang, 2007). The common affordances of mobile devices are: ability to send and receive information in textual, oral or multi-media formats. Thus, from the objective 'support diversity of accessing devices' the meta-design requirements extracted are: MR 4. Implementation of various options reflecting the continuum of communication - texting to multimedia and voice calls.

#### **4.1.3 Meta-requirements (MR) delineated from the objective 'Removal of barriers to participation'**

Ability to initiate and/or engage in a discussion with the moderator and other users requires that the solution cater to the needs of the participant irrespective of their literacy levels or digital skills. Shakeel & Best (2002) have shown that users with varying levels of literacy and digital skills prefer design with iconic interfaces and need audio and visual cues to work effectively. Research has also shown that textual messages are unintelligible to many mobile device users (Lalji & Good 2008). However, visual and audio messages (in the vernacular) are universally understood (Lalji & Good 2008). Issues such as non-uniformity in ICT skill level and the inability to access multi-media messaging format may form another barrier. To overcome this, interaction maybe facilitated by the administrator via both audio and/or visual modes. Thus, system design needs to make use of audio and multi-media messaging features of devices and an administrator intermediary to overcome barriers and increase participation. Thus, from the objective 'Removal of barriers to participation the meta-design requirement delineated is: MR4: Implementation of various options reflecting the continuum of communication - texting to multimedia and voice calls.

#### **4.1.4 Meta-requirements (MR) delineated from the objective 'Facilitate fulfilment of motivational needs'**

A substantial body of work in the domain of social psychology has discussed the distinct motivational dynamics that underpin participation in the social movements. Value-Belief-Norm (VBN) theory (Stern et al. 1999) draws upon the socio-psychological theory of motivations and proposes that norm-based actions (that is, participation and contribution) flow from three factors: acceptance of particular personal values (the values of the movement), belief that aspects important to those values are under threat; belief that their action can help restore those values. Norm activation depends on awareness of consequences (AC) (to self or others), ascription of responsibility (AR) to self for the undesirable consequences to others, thus, leading to actions that alleviate those consequences. Concurring, Batson et al. (2002) assert that in order to ensure proper community participation, invoking a judicious mix of altruism or collectivism motivations is essential. Together, VBN theory and Batson et al. (2002) identify motivations that encourage environmental behavior, generate prescriptions to orchestrate these motivations to increase contributions to the participatory movement. The meta-requirement extracted from the objective 'Facilitate fulfilment of motivational needs' are: MR 5. Provision of services that lead to heightened use of system (by invoking values) and MR 6. Provision of design elements to encourage participant behaviour that supports system objectives. Table 1 lists the meta-requirements and the associated design principles (DP) for system design.

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Meta-requirements	Inferred Design principles
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MR 1. Provision of access to moderators and other participants	DP 1: Ensure users can contact moderator and other participants , via moderator, free of cost
MR 2. Implementation of various options reflecting the continuum of communication - texting to multimedia and voice calls	DP 2: Ensure that participants can communicate with the system via sms, mms, Voice calls
MR 3. Monitoring of context for provision of necessary knowledge	DP 3: Ensure knowledge is stored in categories; participants can access these categories and thus get access to relevant knowledge
MR 4. Provision of procedures to take part in decision making in the context of available knowledge	DP 4: Ensure participants have information about new knowledge in system DP 5: Ensure participants can comment and decide based on new knowledge in system through up/down voting, ranking, etc.
MR 5. Provision of services that lead to heightened use of system	DP 6: Ensure visibility of information related to context (aka local situation)
MR 6. Provision of design elements to encourage behaviour that supports system objectives	DP 8: Ensure feedback on contribution DP 9: Ensure visible display of incentives such as voting, rating,etc

Table 1. Meta-requirements and Design Principles of a Technology-mediated Public Participation System (Robinson & Imran 2015)

## 5 DEMONSTRATION AND RESULTS

A commercially available software, NewsmsLite, was used to instantiate the design prototype in Guntur district, India. 105 participants (54 male, 46 female, 100% mobile ownership) agreed to interact with the design upon receipt of cues from the moderator (lead researcher). The cues were sent in textual, audio and/or multi-media modes and were designed to check the efficacy of a design principle (DP) in terms of participant activity levels (See Table 2). A qualitative research method, case study, identified as an appropriate method of ‘naturalistic’ evaluation (Pries-Heje et al. 2008), especially for understanding the design of the artifact in the real world was chosen. Focus group interviews, recommended as a suitable method of evaluating and for demonstrating the utility of an artifact (Peppers et al. 2012) were conducted, with group membership ranging between 5-11 participants. Practical considerations (participant availability, venue) constrained the number of focus group discussions. Further, 31 participants took part in semi-structured interviews, averaging about 35 minutes each. This number ensured data saturation and adequate data collection for credible analysis and reporting (Marshall et al. 2013). The questions in the interviews sought to elicit the characteristics of a ‘good’ public participatory process as understood by the participants, the relevance and applicability of the conditions for effective participation as suggested by Webler (1995) and the incentives motivating participation for the environment. The transcribed interviews and group discussions data were imported to a data analysing software, NVivo 11. The data was analysed using thematic content analysis (TCA) defined as ‘a method for identifying, analysing and reporting patterns (themes) within data’ (Braun & Clarke, 2006, p. 79). The thematic analysis process is accomplished via a series of steps as per Braun and Clarke (2006 p. 87). Some of the interaction of participants with the design prototype are presented in table 2 (below).

Design Principle (DP)	Cue to Participants	# Cont acted	Responses Received/ Expectation from DP
DP 2: Ensure that participants can communicate with the system via sms, mms, audio	Textual and visual cues (For example, please send in either a picture or a description of any bird, plant or animal you may see in the next 2 days)	97	12 (Calls 5, sms 4, mms 3)

DP 4: Ensure participants have information about new knowledge in system	Visual & textual cues (all participants were either forwarded a photograph sent by a participant or informed of it via text and thanked for their contributions)	97	No action required
DP 5: Ensure participants can give comment and decide based on new knowledge in system through up/down voting, ranking, etc	Textual & visual cues sent to all participants suggesting any comments on new information in system (as informed previously)	97	Requires participants be aware of information in system and be motivated to respond
DP 2: Ensure that participants can communicate with the system via sms, mms and/or audio	Textual & verbal cues (Understanding the effect of verbal cues on participation rates: post calling and talking, (phone number not 'fed' into their device)	37	3
DP 1 New: Ensure users are made aware of a trusted moderator via an initial invitation to participate in system	Understanding the effect of trusted moderator on participation rates post-group meetings (phone number 'fed' into their device)	40	15 (calls 2 sms 10, email 3

Table 2. Participant Interaction with Design Prototype

## 5.1 Participant feedback

Analysis of data gave rise to expected themes outlining an optimal participatory process: access to the process and ability to influence process (Webler 1999), structural characteristics to facilitate constructive interaction (Webler & Tuler 2001), proper representation (Xu et al. 2006) and involvement of traditionally marginalized groups such as lower castes (Kapoor 2001). The unexpected major thematic categories by frequency of reference were 'Nammakamu', 'group competence', 'participation dichotomy' and 'basic needs satisficing'. In the following sections, we discuss the first two unexpected themes in the socio-cultural dimension, translation of the themes in the information and communication technology (ICT) dimension and finally, implications to the normative theory of public participation; those relating to the VBN theory are discussed in a forthcoming paper.

### 5.1.1 Nammakamu

All participants in the study used one word - 'Nammakamu' - loosely translated as trust, not as in trust in an individual but encompassing something broader - a notion of trust that is conferred upon as well as received by the individual, to make them one of the 'Big-men' (in this study, all 'Big-men' were male).. Studies in developed countries (Lauber 1999; Webler & Tuler 2001) have shown that a participatory process is viewed as one facilitated by planners, with participants forming a democratic, deliberative body. The feedback concurred with the results of research from developed countries and suggested that procedural characteristics of the process such as 'was everyone invited to participate/informed of the activity?' are important. But, it differed in the importance placed on the role and nature of process planners. The participants overwhelmingly sought to cast the process planners as representative of the process with participation contingent on whether or not these planners were elders 'Peddalu'/'Big-men' of the community. The concept of 'Peddalu'/'Big-men' in the culture is drawn from the vocabulary of terms designed to explain leadership in the south Indian context (Mines and Gourishankar 1990). 'Nammakamu', as used by the interviewees when referring to the 'big-men' consists of an interplay of two dimensions - a shared 'exterior' or 'known' and an 'interior' or 'felt'. The shared exterior dimension consists of what people 'know' about the 'big-men' based on experience or their reputation. It is expressed in interactions between people. The interior dimension consists of what the 'big-man' feels and projects as his 'self' in interactions with the wider community and consists of his interests, motivations and a sense of understanding of the broader world. This mirrors the idea of social capital, but in the context of an individual (Krishna 2004)

*“...people in the village will decide who is the big-man... ... people who can command the respect of others, who can communicate with the community members, who can make others feel motivated to act for a cause .. it is not related to financial status, though it does help if that person has the ability to help in need.” (Respondent 9) “people need to have nammakamu in us first - they need to ask: if we give this per-son a task can he complete it successfully with fairness, legality and in the right way.... people will know and recognise who is the big-man...” (Respondent 10, considered by other interviewees as one of the ‘Big-men’ in Narnepadu village)*

### 5.1.2 Reconstitution of IS innovation within the Socio-cultural Context: ‘Nammakamu’ as a mantle on the technological artifact

The cultural construct of ‘Nammakamu’ seen as a necessary condition for participation in physical space was translated in the context of the technological artifact. The initial low participant interaction with the instantiation is explained thus:

*“...everyday I get between 10-15 messages. I get company offers all the time, so I also do not check my messages....I do not see messages if I do not recognise the names” (Respondent 3)*

But the participants did offer to interact with the instantiation under certain conditions:

*“...If you want to see how this group reacts (to the design instantiation), send the sms to me and I will forward it them; they trust me as I am on their phones. They will not respond to your (researcher) sms as they will not recognise it nor will they even open it...” (Respondent 28, one of the ‘Big-men’)*

As a reaction to the unwelcome intrusions in the digital world, participants envelop the digital space afforded by the technological artifact with a mantle consisting of the locally understood and negotiated socio-cultural mores such as ‘Nammakamu’ to give rise to an emergent culture of ‘mobile phone use’.

### 5.1.3 Impact on design

In this context, the normative theory of public participation does not fully account for the antecedents associated with assessing the ‘fairness’ of the public participation process: the need for a ‘trusted’ moderator. In a public participation system, it is not possible for all participants to know of a single trusted moderator; hence, a need for multiple moderators, each with their own network of participants, and, engaging with a trusted coordinator. Translating this to meta-requirements (Table 3):

- Provision of procedures to nominate/select trusted moderator from a set of moderators within the system
- Provision of procedures for access to a trusted moderator and through them, to other participants in the system

Meta-requirements Pre-evaluation	Meta-requirements Post-evaluation
MR 1. Provision of access to moderators and other participants	Provision of procedure to nominate and/or select a trusted moderator within the system
	Provision of access to a trusted moderator and through them, to other participants within the system

Table 3. Revised Meta-requirement 1 for the Technology-mediated Participation System

### 5.1.4 Samardhatha - Individual and Group Competence

A system design that enables access to, and analysis of, all required information thus leading to desirable actions is indicative of a competent participatory procedure (Renn et al. 1995). An analysis of participant interviews reveals something different: it is not necessary to analyse all the available information in order to arrive at a conclusion. What matters is whether, as a group, the participants are able to competently analyse information and come to a desirable conclusion. Each individual participant has their own skills and talent, which is utilised in their area of expertise, thus each individual’s samardhatha (competence) aids the group in arriving at a satisfactory conclusion for the whole.

*“It is very important that the person with the right capability address a given issue; so, even if they do not have a good reputation in the village, if they are capable in something, I will definitely like them*



*in the role that requires possessing that specific capability.” (Respondent 18); “In any of the programs we were part of, usually one person dealt with under-standing financial issues, another sorted issues around working capital, another person made decisions on who is better at deciding particular aspects and so on. usually we make sure they are appropriate and have the talent to do that task. Thus, we are very careful when coming to a decision that only the necessary people are taking it.” (Respondent 14)*

### 5.1.5 Reconstitution of IS innovation within the Socio-cultural Context: ‘Samardhatha’ as a mantle on the technological artifact

Even though most of the participants were not comfortable or familiar with using the multi-media messaging feature on their phones, they were ready to act on cues sent through the design instantiation by what-ever means their devices were capable of. A few examples from field notes illustrating how the participants decided to report on researcher’s cues:

*“I do not have net card on my phone but I saw this nest in a tree in the field, so I took photos of it. Here, can I blue tooth them to your phone?” (Respondent 8) “I cannot take photos with my phone but that is not a problem, I can come to you and tell you what I saw.” (Respondent 2)*

This is another example of emergent culture - the transposition of participatory behaviour in a socio-cultural context onto a technology artifact, to give rise to new and unexpected outcomes.

### 5.1.6 Impact on design

The desire to be part of the participatory process and assist in the resolution of issues or, completion of an activity has led the participants to not shy away from performing any task that advances the outcome of the participatory process. Participants reiterated that this need satisfaction is important. Whereas normative theory of public participation suggests that an optimal participatory mechanism ensure procedural competency in participants, our study reveals that the participants have modified the concept of procedural ‘competence’ to include not just the ability for decision-making based on available knowledge, but also the ability for ‘sense-making’ and for providing piecemeal ‘assistance’ based on individual’s available knowledge. Translating these into meta-requirements (Table 4):

- Provision of procedures to take part in decision making in the context of available knowledge
- Provision of procedures for sense-making in the context of all available experiential knowledge

Meta-requirements Pre-evaluation	Meta-requirements Post-evaluation
MR 4. Provision of procedures to take part in decision making in the context of available knowledge	Inclusion of procedures for sense-making  Procedures to list all tasks/aspects of decision making that require completion/addressing; procedures to nominate all tasks/aspects of decision making one can assist with  Provision of procedures to take part in decision making in the context of all expert and experiential knowledge

Table 4. Revised Meta-requirement 4 for the Technology-mediated Participation System

## 6 CONCLUSION

Developed countries have shown that opportunities for solving large-scale problems can be enhanced by involving public via technology-mediated participation systems. In order that the developing countries may also avail of these opportunities, this research embarked on designing a system fit for the context. A prototype design framework was instantiated and evaluated qualitatively using case study method. Additional meta-requirements surfaced from the analysis. The normative theory of public participation, a type IV theory (Gregor & Jones 2007), proven in a pluralistic, democratic setting is shown to be inadequate in explaining the antecedents leading to optimal public participation. Informed by these new revelations, revised meta-requirements for design are presented. Future research will entail collecting empirical evidence to a) test the revised design framework and b) test the inductively

confirmed additional antecedents associated with the normative theory of public participation in the context. Given the proliferation of new forms of ICT, there is still a lot more to be discovered regarding ensuring optimal public participation and the perfect design for enabling it. Our work continues.

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