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Emergence of perceptions of smart agriculture at a community/campus farm: a participatory experience

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Abstract

This study provides a practice insight into campus/community co-farming as a communication experience connecting civic participants and experts in exploring the potential applications of smart agriculture. The observation focuses on participants' perceptions of smart-agri practices. The objectives of smart-agri practices have been identified to reduce negative environmental impact and meet local challenges; their development corresponds to the civic value-driven experience of promoting sustainable agriculture with low-risk, trackable information. Relatively few studies on smart-agri communication have engaged with the non-expert level. The findings highlight a viable participatory communication form of problem-solving, the public's trust of expertise, and a vision for inclusive socio-economic applications of smart agriculture.

Keywords

Community action; Participation and science governance; Public engagement with science and technology

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Introduction

Global agricultural development includes a resilient, reliable, and trackable agri-food system used in the present era to cope with extreme weather, growing demand for food, and limited natural resources. In the current trend of innovation that seeks to accommodate risks and needs, such as CAS (climate-smart agriculture), agricultural productivity has been enhanced through integration with technologies, mechanical equipment, sensors, AI, internet services, and so on. In this study, the term smart-agriculture (smart-agri) refers to the integration of assistive devices or crop improvement research in the agri-food supply system and the applications used to address local issues and conditions [De Sy et al., 2018; Taiwan Agricultural Research Institute, 2021]. Studies have pointed out that smart-agri is not confined to technical practices but is best defined by its objectives of being appropriate to the local needs and operating in a safe and low-risk manner [De Sy et al., 2018; Taylor, 2017]. Associated with precision farming of irrigation or fertilizer management, smart-agri is noted to contribute to sustainable agriculture concerning a healthy environment [Campbell et al., 2014]. In light of the traits of smart-agri, the perceptions of smart-agri investigated in this study are related to its objectives, focusing on the motivation to engage with and perceived benefits of smart-agri innovation.

Current smart-agri policy practices focus on government efforts to manage price fluctuations, food pressure, and workforce shortages at the production and industrial levels [FAO, 2016; Patil and Kale, 2016; Raile, Young, Bonabana-Wabbi et al., 2018]. Nevertheless, the significant features of smart agriculture, which emphasize innovative strategies for coping with challenges such as climate change and the aging farming workforce, alongside ecological benefits, have huge potential to offer effective applications to support non-industrial-scale agriculture and fulfill local needs. The technologies and scientific information are extremely relevant in assisting public consumers to make personal choices and obtain locally grown and organic food. Communicating the implications of smart agriculture practices at the public level extends their impact on agri-food policies, including the national agenda of research and regional support [Raile, Young, Kirinya et al., 2021]. In this study, the aim is to investigate how to communicate to local community members about smart agriculture. It addresses three questions:

1. How can a viable participatory form be introduced to promote a conversation based on campus/community farming practices?
2. How is expertise regarding the new farming methods identified and trusted?
3. What is the public vision of smart agriculture? Are there any social "echoes" of the movement?

In this study, a campus farm was set up in a port-industrial city of immigrant residents where community members retain a shared memory of traditional farming methods. It investigates the ways in which a campus/community farm provides a platform for communicating both the cognitive and affective aspects of smart agriculture for small farms. This study explores the use of campus-site co-farming as a participatory practice to facilitate local community members' interactions and conversations. The research focuses on the impact of their participatory experience in relation to the emerging perceptions and attitudes of the applications of innovative technologies and policies.

Literature Review

Community farming for participatory communication

Community farming practice involves a variety of participants, who are working on and experiencing the process of social change [Artmann, Sartison and Vávra, 2020; Dutta and Chandrasekharan, 2017; Lyson, 2004; Pagliarino et al., 2020; Strunk and Richardson, 2017]. A community farm is communal and collective in nature and involves civic participants of different ages, genders, and cultures. Participation in community farming has been linked to civic agriculture that promotes localized agriculture, which offers economic and ecological benefits [Lyson, 2004; Pagliarino et al., 2020]. As public participation is the core objective and fundamental component of setting up a community farm, community farming projects are widely perceived as having an impact on local residents' lives by encouraging them to form social relations through engaging in interactions and conversations. Community participatory projects stimulate a close collaboration between the land and people, and convey positive messages, including around health, empowerment, and community identity [Strunk and Richardson, 2017]. Also, being hands-on and proactive by nature, community farming involves participants familiarizing themselves with a broad field of scientific knowledge [Pagliarino et al., 2020], from soil to climate and farm management to food consumption, as part of the process of co-working to grow crops for community projects.

A community farm epitomizes social issues and the need for new approaches; it shows that civic action can provide a solid foundation for scientific-social development [Dutta and Chandrasekharan, 2017; Seddeek and Krishna, 2019]. It examines emergent technologies and policies in relation to mutual, civic benefits across the objectives, operational strategies, design, and outcomes [Haywood and Besley, 2014; Leach et al., 2012]. For the community, farming practices offer the aspects of life experience, memories, an expectation of the area's development, public health, and local residents' wellbeing [Kingsley, Foenander and Bailey, 2019]. Such strong core values are the heart of civic participatory agriculture, which distinguishes community farming from leisure or industrial farming.

The dynamic of the participatory approach in seeking the best or most efficient methods for the community farm is implemented through dialog [Kurath and Gisler, 2009]. The unique dynamic of engaging local members in the on-site farming practices stimulates a constant dialog, exchange of knowledge, and negotiation, as "only dialogue, which requires critical thinking, is also capable of generating critical thinking. Without dialogue, there is no communication, and without communication, there can be no true education" [Freire, 2009, p 65]. Dialog leads to a community-led response to challenges. Dialog among the local members leads to communication in the search for solutions [Lyson, 2004]. Locally initiated dialog explores diversity and differences, which opens up more possibilities and innovative strategies [Leach et al., 2012] and also initiates change.

In this study, dialog among the local members was stimulated by identifying problems and negotiating possible solutions to them. Expertise was introduced to foster participatory science communication about new ways of farming. Expertise offers pragmatic practices for solving problems and engaging in debate regarding the identification of appropriate farming strategies. Research has observed that experts are a guiding element in engaging non-experts in contextualizing scientific knowledge and real-life experience [Kurath and Gisler, 2009; Haywood and Besley, 2014; Hadorn et al., 2008]. The role of experts and expertise in participatory science communication is not to stress the deficit of knowledge but to help the public to analyze and approach real-world problems of high uncertainty. The participation of experts reinforces knowledge exchange and works to catalyze viable forms of transformation.

The mechanism of participatory communication involves introducing multiple perspectives and a variety of stimulations; the meaning of a public issue is then debated and amplified [Lengwiler, 2008]. In contrast to industrial farming, which is led mainly by the expertise of governments and corporations, the participatory approach is led by the general public on community farms [Dutta and Chandrasekharan, 2017; Scharinger, 2013]. Community/campus farming engages civic agriculture activities which stress social interaction, responsibility, and problem-solving inquiry for sustainable agriculture [Lyson, 2004]. The civic farming site captures the public efforts to approach issues via a regional vision, cultural identity, and common appeal [Kingsley, Foenander and Bailey, 2019]. The participatory process appeals to a collective perspective and individual expression in response to the expertise perspective.

In this study, the participatory approach involved both the public and experts visiting the community/campus farm to discuss and shape the current and potential applications of smart agriculture. The communication was focused on technology development, strategies for applications, and policy-making directions. In this study, the public's cognitive and affective understanding of these three dimensions was investigated.

Objectives of smart agriculture and communication

Current studies on smart agriculture mainly focus on its application to support agri-food production, especially in light of climate change [FAO, 2016]. Governmental power institutions appear to be guiding the policies to develop smart agriculture [Lipper et al., 2014; Raile, Young, Bonabana-Wabbi et al., 2018]. The contribution of smart-agri devices, especially climate-driven agriculture, has been to enhance the resilience and regional productivity system of agri-food [Olawuyi, 2021; Raile, Young, Kirinya et al., 2021]. Communication about smart-agri to appeal for public support and vision of the benefits of smart-agri will extend its application at the level of local and small farmers.

The public, as the facilitator and supporter of the new smart-agri-tech, has yet to be activated and remains to be investigated. Participatory science communication implements the public's expectations of social change [Artmann, Sartison and Vávra, 2020; Kurath and Gisler, 2009; Leach et al., 2012]. An innovative form of smart agriculture needs to include and inform a diverse range of participants to examine its responsibilities and values, alongside providing an infrastructure to secure agricultural profits. The communication of smart agriculture has been integrated with the female leadership and the governance of the stakeholders [Raile, Young, Bonabana-Wabbi et al., 2018]. In this study, the observation focuses on civic value-driven perspectives on the potential applications of smart agriculture. It examines the inclusivity, representativeness, and social benefits which increase the potential of innovative technologies and a more grassroots direction of governmental policies for investment, as revealed through the participatory approach of civic agriculture.

Framework of this study

Figure 1 shows the theoretical framework proposed in this study. The framework shows that the participatory process is expected to communicate scientific aspects and enhance the public/consumers' perceptions.

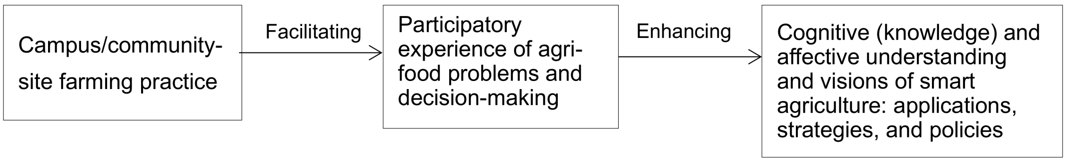

Figure 1. The framework of this study.

Case study: Activating participatory communication of farming

The participatory communication in this study was initiated by dialog and small-scale practice [Kurath and Gisler, 2009]. Participatory communication was activated by the pragmatic problems that arose during the hands-on farming process and the constant civic debate about the problems. In this project, the civic participatory activities were observed rather than planned, from September 2018 to date (with a pause during the Covid-19 lockdown from May to September 2021). In light of shaping a participatory culture [Jenkins et al., 2013], special attention has been paid to maintaining the process, following the guiding principles:

- low barriers to crop-growing results and the requirement of involvement,
- encouraging support for sharing thoughts or products with both participants and non-participants,
- informal mentorship, whereby invited experts are introduced as experienced participants,
- the participants' contributions matter and are recognized.

Overall, participation is the social connection of science learning and communication [Haywood and Besley, 2014]. The inter-functional components of the ecological and socio-economic dimensions enable community farming to accommodate a variety of professional participants and stakeholders from various fields — agricultural experts, educational practitioners, green industrial producers, and civic consumers.

The initial motivation to set up the farm was a desire to rejuvenate a rundown campus area that had been damaged by a typhoon, funded by the researcher's science education project related to agri-food security. The location is open to the public and allowed the civic participants to meet and exchange ideas (a quasi-"agora", Lengwiler, 2008). The farmland patch in this study is approximately 90 square meters, which is manageable and allows everyone to work, discuss, and observe the soil's maintenance and bio-habitat (Figure 2 and 3). The community members are involved in the farming practices, from the choice of crops, land preparation, crop growing to harvesting. To announce the dates of the farming activities, a simple hinoki wooden signpost (safe from termites) was designed and put in place. It displays regular posts about agri-food-related knowledge by the students.

Involving the staff and local residents was a spontaneous process. The choice of which crops to grow was the main topic of discussion, which encouraged various

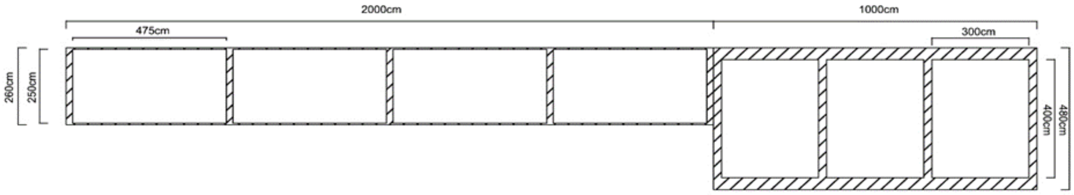

Figure 2. Plan of the campus farming area.

Figure 3. Panoramic view of the campus farm.

participants to communicate and make collective decisions. Improving the soil health was also constantly discussed, as the farm is by the sea and so the land tends to become hard following exposure to sodium and strong sunshine. Farming skills therefore are crucial for growing the crops. The process includes the following actors:

Students. The campus farm was originally initiated to allow undergraduate students to engage in a hands-on project related to sustainable agriculture, and to make the farmland a showcase for local seasonal crops.

Staff. The university staff who walked by on a daily basis started to participate in helping to fix the irrigation system, compost-making, pesticide prevention, crop recognition, harvesting, and sharing the produce.

Local residents. The campus has long been a popular location for community residents to take daily walks, engage in outdoor exercise, and socialize. The residents observed the farming methods practiced by the young students and staff, and began to take photographs, help out, and learn. They also offered traditional farming tips that they recalled from their childhood.

Experts. Expertise was introduced in the pragmatic process of advising on solving problems and joining the civic debate. To decide which seasonal crops to grow, solve farming problems, and understand how serious the problems are, the civic participants had to find solutions and put them into practice. The experts were then invited to join in the problem-solving process. The participants proposed questions and solutions, and the efficiency of the solutions were reviewed or new strategies were introduced by the experts for further discussion. The process appeals to broader fields of expertise; in the case of this study, IoT engineering scientists, marine biologists, journalists, social workers, green restaurant chiefs, and governmental officials came along to introduce themselves and discuss new strategies and policies with the participants. Taking a conceptual irrigation system design as an example (Figure 4), the plan involved participatory experience, including collecting a variety of data (soil, crop types, local and international advanced devices, cost, agri-food policies, etc.), modifying and fortifying the operational efficiency.

In summary, the participatory process was essentially based on problem-solving and the discussion of new strategies.

Figure 4. Setting up an irrigating practice.

Participants

In this study there were three types of civic participants: students, university staff, and local community residents (Table 1). There were 286 undergraduate students ranging from 1st to 4th years (aged 18 to 22 years-old), consisting of 191 male and 95 female students, studying a variety of major subjects. The student participants were recruited at the beginning of the fall and spring semesters and asked to enroll in a sustainable agriculture course. A total of 14 staff participated regularly (weekly for more than two growing seasons), consisting of 5 males and 9 females. They were from a variety of academic, administrative, and service departments of the university, including teaching and research staff, secretaries, and coffee shop and photocopy shop assistants. A total of 11 local community residents regularly participated, consisting of 5 males and 6 females. Their professions included artist, businessperson, fisherman, housekeeper, market vendor, and retired teacher. The local community participants included in this study participated in the farming activities regularly (on a daily/weekly basis) from autumn 2018 up to the 2021 spring season. Due to controlling the participation frequency, the number of local community participants was relatively small, albeit representative of the farming situation; however, the small sample size was appropriate when adopting case-study approach and generating an in-depth understanding of the on-site participation experience.

Table 1. Profile of the participants.

Types	**Categories**	**Options**	**n**
Students (ST)	Gender	male	191
		female	95
	Major	humanities/social sciences	120
		science/engineering	166
University staff (STA)	Gender	male	5
		female	9
Local residents (LR)	Gender	male	5
		female	6

Data collection and analysis

In this study, two qualitative methods were employed to collect longitudinal narrative data. The first was the researcher's observation recording diaries regarding the participatory engagement dialog; the second was focus group interviews regarding the participants' reflections and expectations. The data were collected from September 2018 to May 2021.

The observation method adopted a fieldwork study method to observe and document the civic dialog and interactive situations on site at the campus farm. The observation documents focused on the following: areas of the campus farm, co-farming working time, types of participants, crop-growing situation, interaction process, topics of the dialogs, and participants' self-reported questions and reflections [Crang and Cook, 2007]. The analysis of the observations focused on the three indicators of inclusivity, representativeness, and mutual benefit of the participatory process [Haywood and Besley, 2014] to understand the dialog that the civic participants engaged in to communicate aspects of expertise and solutions.

Focus group interviews were organized at the end of each growing season, after the crops had been harvested and tasted. One to six voluntary respondents were invited from each group of participants (students, staff, and community residents) to discuss further their participatory experience, mainly focusing on their reflections and visions of the benefits of smart-agri related to their participation (Figure 5). The interviews lasted 90 minutes, with the researcher acting as the moderator. A list of questions based on the debate, problems, and compromises that occurred during the farming season was prepared prior to the meeting to prompt reflection and elicit detailed views from the respondents. The discussion was audio-recorded and written notes by the moderator and interviewees were collected. The results of the focus group were used to provide in-depth information to sharpen the researcher's observation to obtain insights into civic-experts collaboration.

Figure 5. Focus group interview with local participants.

Findings and Discussion

The analysis of the narrative inquiry was guided by the three proposed research questions concerning responsive civic participation, the public's trust of expertise, and the visions of the benefits of smart-agri that emerged. The major findings are identified and discussed in the following sections.

Problem-resolution practices activating participatory science communication

In this study, the farming experience involved a series of problem-solving negotiations and hands-on operations by and for the civic participants. Major issues regularly led the public to engage in "lengthy" discussions on site across the generations. The motivations for the use of smart-agri or precision farming strategies are categorized as below:

1. Workforce. "The birds peck the seeds swiftly and there are not enough of us to watch the birds; we'll miss the season of growing crops" (2019s-ST) and "it takes lots of people and time to work on nursery seedlings and saplings and to hand-clean and recycle the trays and plugs" (2019s-ST).
2. Environmental health. "What can be put into the farm to fertilize the soil?" (2018f-STA), followed by a discussion of less smelly (but not rich enough) compost-making using campus weeds, a debate about the brands of organic fertilizers, and physical or chemical-related solutions, like "We have lightning to increase nitrogen already. We should work more on the heat, light and sound, control, that is safe, non-polluted, and non-poisonous to increase the efficiency of growing crops" (2018f-LR).
3. Crop growing and care. Support for different methods, especially regarding pest-control issues, including "We should grow herbs to improve pest control" (2019f-STA), "Ashes, diluting alcohol, soda water" (2019f-LR), "Applying more often suribacterium and bacillus subtilis" (2019f-STA), and "Let's set up sticky boards to see the species and amounts of insects, nets and light to lure them" (2019f-ST). All of the possible methods proposed were applied at certain points and the best combinations for suitable plants and different pest species are an on-going civic experience.
4. Landscaping. "The height of the quinoa, corn, and cassava should be aligned for beauty" (2019s-STA), "Plenty is beautiful" (2020f-ST) vs. "A wide gap between the crops nurtures the plants better" (2020f-LR), "Keep the plants

growing for smaller but more collections" (2021s-ST) vs. "Trim the branches and flowers for better quality results" (2021s-LR), and "Growing some easier maturing crops will make the harvesting more satisfying and the hard work more rewarding" (2021s-STA).

5. Climate adaptation. "It is very risky to grow melons now as we aren't sure if there'll be a drought or typhoon" (2019s-ST), "Do we have the data or past records to calculate the possible time of growing?" (2019s-ST) and "Can we find the kind of wheat that can be grown in constant rainy or flooding situations?" (2019s-ST) (A new breed that is tolerant to tropical humid weather is available locally.)

It was observed that the participatory communication derived from a need to express problems in the daily context and the need to express opinions about potential solutions to these. The public consensus and decision-making dialog were enhanced by scientific evidence and knowledge. Monitoring strategies were organized, and farming skills and equipment were tested, installed, or created.

The "deep" participation of functional decision-making engaged in a solution-seeking process takes a certain amount of time to engage the actors in collective thinking, learning new knowledge, and reflecting on the problems encountered, especially in relation to the ecological and socio-economic context. *The higher the number of the participants, the more varied the details and branches of scientific knowledge that were communicated*.

Expertise is trusted and welcomed — Not my way or your way

Lengwiler (2008) remarks that the participatory communication between experts and non-experts has the mission of advancing the socio-economic implications of science and technologies. Hands-on problem-solving opens up the dialectic process between non-agricultural scientific participants and experts. On the campus farm, the invited expertise theoretically explained participants' solutions, extended knowledge, and outlined strategies for introducing knowledge on new technologies. Communication between experts and non-experts corresponds to the micro-level of problem-solutions and the macro-level of policy practices and assessments.

In this study, the experts who participated were organic farmers, formerly serving in South America and the Middle East in diplomatic agricultural organizations (thus knowing how to engage in organic farming under a variety of natural conditions), researchers from the council of agricultural research stations (crop cultivation), and officials from the agriculture bureau (marketing, workforce, policies). The participants' responses expressed their understanding that the role of the experts was to communicate the scientific conceptions, pragmatic solutions, and governmental policies related to agricultural development:

> "The experts' intervention introduced a set of systematic strategies and matching devices... they drew our attention to the impact of climate change, energy resources, technologies and applications related to crop growing." (2020f-ST)

> "Their [the experts'] solutions should be helpful for supporting the living of the smallscale farmers... maybe we can report their methods at the staff meetings to be applied to other areas of the campus." (2019s-STA)
>
> "I think the experts can help to solve poverty issues for smallscale farmers." (2019s-LR)
>
> "The more advanced farming devices and research are able to reduce the use of pesticides.. agriculture is being transformed... our products and the market ones all tasted better and healthier." (2019s-LR)

Participatory approaches help to frame the problems of science and technology within the socio-economic context and invite the actors to form an appraisal of these. The participation of expertise and experts in this study was positively welcomed by the civic participants as an opportunity for "learning advanced knowledge to do something". However, there is a potential limitation related to introducing experts, which may close down the problem-solution process. *The civic participants tended to comply with, show a commitment to, or make concessions about their own strategies*. Such a negotiation process is also observed in participatory studies [Lengwiler, 2008]. When experts with "scientific authority" engage in participatory communication, therefore, it is vital to open up a diversity of possible approaches to tackling the challenges, which remain stimulating and foster the public's dynamic dialog and imagination.

Perceived benefits and vision for smart agriculture

In this study, the campus farming activities were constantly dubbed and compared to a popular digital game version of "Happy Farm". This popular perception was reflected in participants' reactions in their concentration, excitement, engagement, freedom, skills, and kinesthetic energy. The participants' vision for the new agriculture and policies was broad and everchanging, but had a strong identification with and multi-dimensional expectations regarding the development of smart agricultural technologies as effective solutions to their problems:

> "For all academic majors, data collection and information analysis can contribute towards securing food resources for balanced production." (2020f-ST)
>
> "The younger generation is good at using computers, so using technologies will help young people to return home to work on agriculture and have a good income... it [agriculture] is the root to support all sorts of development." (2019s-LR)
>
> "Science and technologies make delicate agriculture; food has become so delicate compared to that in our childhood... it is delicate and hygienic with pesticide tests and control." (2019s-LR)
>
> "The government should support and monitor the research on agricultural technologies, which will offer the benefits of saving water, saving labor, reducing the public's fear of an unstable food supply and unstable prices... for example, the green house subsidies helped the prevalence of organic farming, so the government, local agricultural bureau, and the farmers should work together to improve and apply the technologies to secure the social and economic stability." (2021s-STA)

The perceived benefits, from the participants' perspective, of the smart-agri applications enhance the development of sustainable agriculture. The expected contributions also demonstrate the ways in which smart-agri practices will be trusted by the public. The expressed benefits of the smart-agri innovation are classified in Table 2.

Table 2. Vision for smart-agri.

Dimension	Vision of the benefits
Natural resource	Trusted scientific solutions regarding less-exploited land and water resources
Social innovation	– Rejuvenating rural farming areas through appealing to the younger generation to participate – A better working environment and labor-saving for farmers – Corresponding information between consumers and producers
Economic strategies	– Advancing the efficiency and productivity of small-scale organic farming – Securing healthy food production under extreme weather conditions – Farming in the local urban area for a low carbon footprint food supply

Conclusions

The results of this study indicate that participatory campus farming activates a dialectic experience of communication about knowledge and applications concerning scientific and social development.

This study concludes that campus/community farming functions as an avenue for cultivating science identity through participatory communication that connects the civic participants with experts in a dialectic process of understanding the conceptions of smart agriculture. Participatory science communication promotes a positive cooperation of trust that extends the scientific-technological applications to the socio-economic level.

The participatory communication experience is powerful in relation to its appeal to non-experts to recognize the resourceful implications of the expertise, and to identify with the experts and the scientific knowledge presented. In the case of this study, the significance of the scientific-technological strategies is revealed in the process of civic participatory agriculture. The participatory action of crop-growing on the campus farm represents an inclusive, collective, and pragmatic practice of a dialectic communication, expressing the public's desire for the mutual benefits of local and smart agriculture. The trust in the expertise represents a common appeal for problem solutions, identified with sciences and technologies that have a shared responsibility for promoting change in the existing policies and values.

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