Understanding rural Do-It-Yourself science through social learning in communities of practice

Abstract

The structural shift created by recent technological developments has resulted in the rise of Do-It-Yourself (DIY) science. Although DIY science has been useful in terms of explicating maker-movements within developed countries, its usage in a rural context is still unexplored. This paper aims to examine the usage of DIY science within a developing country. By using a case study approach, this paper explores how a culture of DIY science is cultivated and spread through a Community of Practice (CoP) among rural cattle farmers in Bojonegoro – Indonesia. We propose a conceptualization of CoP based on the Habermasian model of communicative action in order to focus our attention to the cultural production of rural DIY science. We argue that the applicability of DIY science is more valuable, in terms of its usage, in developing countries where such innovation systems are pivotal for development outcomes. By examining DIY science in rural contexts, we also show that its utilization also implies a more settling nuance that emphasizes the positive values of innovation that can ultimately create avenues of empowerment and thus promote welfare creation.

1. Introduction

The discourse of Do-It-Yourself (DIY) science has gained prominence due to its attractiveness as an alternative space for "informal" learning beyond the traditional boundaries of universities, pulling talents across the vast disciplines of science and technology (Hecker et al., 2018). Settings that are referred to as "DIY laboratories" challenge classroom education by using unconventional learning spaces such as museums (Ellis and Waterton, 2005) and private homes (Meyer, 2013) to share and discuss specific scientific questions or phenomena. Thus, even "amateurs" in the field of research can now conduct complex scientific experiments, and also contributing to what is referred to as citizen science (Sleator, 2016a).

The concept of "Do-It-Yourself" initially emerged to describe the spread of household self-production as a common social practice in the late 60s and 70s, and recent trends have utilized this term to refer to "the process initiated by individuals and groups that tinker, hack, fix or recreate objects and systems out of their own interest, curiosity or need, and openly share results and outcomes in their networks" (Nascimento et al., 2014, p. 4). The heterogeneity of this expression in terms of its usage in various domains involving various social actors (Alper, 2014) not only resulted in different applications of the term DIY science, but it has also given rise to the diversification of its conceptualization (Ferretti, 2019). Although this has led to some confusion about its fundamental meaning and implications, it also presents us with an opportunity to develop and expand the growing literature of DIY science. However, it is important to point that here we are less interested in seeking a universal understanding of the term itself (see Ferreti, 2019), rather we would like to focus our attention to how DIY science can be postulated in differing contexts.

The premises on which conceptualizations of DIY science are based upon relies heavily on cases of high technological disruption from the realm of biology (Sleator, 2016a, Sleator, 2016b, Davies et al., 2015, Delgado, 2013, Busch et al., 2016) to general technological advancement (Tofel-Grehl et al., 2017), conducted by self-taught learners outside the conventional formality of schools or universities. Beyond the potentiality of DIY science in terms of innovation and technology advancement (Seyfried et al., 2014), there are also growing concerns over several issues, for example, regarding its ethical implications (Fiske et al., 2019), operations and regulations (Ferretti, 2019). However, beyond its capacity in explaining the emergence of a new tradition, of locally embedded innovation process

creation in developed countries, studies on its applicability in rural contexts are still absent. As such, the perceived negative effects of DIY science might not be much of a concern within these settings. We argue that the applicability of DIY science is more valuable, in terms of its usage, in developing countries where such innovation systems are pivotal for development outcomes. Moreover, in examining DIY science in rural contexts, we also show that its utilization emphasizes the positive values of innovation that create avenues of empowerment and thus promote welfare creation.

Our research thus focuses on DIY science in farming systems within developing countries, as the adoption and development of new technologies and practices are crucial for them to ensure long-term sustainability (Tonts and Siddique, 2011). While direct knowledge and skill transfer from government agencies was long seen to be an effective way to ensure farmers' competitiveness, the worldwide push for economic liberalization and economic reform in the 1990s has highlighted the importance of farmers organizations in driving transformation of the agricultural landscape in most countries in the world (Anil et al., 2015, Faure et al., 2019). One essential strategy that is currently being promoted in sustainable development is the farmers' participation in research, development and extension as means to enable farmers to take control of both the adoption and dissemination of knowledge that are required for innovations as a form of empowerment (Eidt et al., 2020, Anwarudin and Dayat, 2019). The farmers' role is not simply restricted to passive participation, but it also involves a direct and active engagement to learn and organize their experiments and development activities (Gianatti and Carmody, 2007, Morgan, 2011, Kalra et al., 2013, Snapp and Pound, 2017). Considering the term DIY itself as a culture that has evolved in offering new opportunities of its utilization in multiple domains such as arts, crafts and politics (Lowndes, 2016), this study examines its operations in the realm of agriculture and development. We postulate the significance and importance of DIY science in rural societies by highlighting its potentiality in farmer system groups as these organizations are increasingly taking a proactive role in promoting grower-centred innovation processes in agriculture (Anil et al., 2015).

The research question we therefore pose in this paper is how can a culture of DIY Science be cultivated in rural contexts? As an effort to answer this question, we follow authors that have attempted to conceptualize the emergence of DIY science in rural contexts of developing countries as a social phenomenon (e.g.Sleator, 2016a) by framing the concept as a culture of innovation that is rooted in a shared identity. We argue that by basing our analyses on the bodily work of communities of practice as a model of social learning, we are able to further explore how this modality has given rise to knowledge acquisition and dissemination across actors who create and negotiate their own meaning of DIY science. This paper also examines a wider nexus of the social learning system that includes various external actors who assist the production and reproduction of the DIY discourse among farmers. Similar to Wangel (2011), rather than focusing on the "what" (objects of change) and "how", we are able to broaden our analysis of social structures by also focusing on "who", i.e. the agents that are capable of allowing change. By analysing interactions, inside and outside a community of practice, with the assistance of the Habermasian concept of communicative action, focusing on how a culture of DIY science can be produced through these networks of interactions, this paper hopes to start the discussion of DIY science in rural contexts.

This paper documents a group of farmers in East Java, Indonesia, located in the rural region of Kedungadem, Bojonegoro, selected as a case study for this research. The group has emerged as a central player in the Indonesian agriculture landscape. They are pioneering members of a program called "*Sekolah Peternakan Rakyat*" (SPR), loosely translated to English as "Farmers' Breeders School", conducted by one of the leading agriculture universities in Indonesia, *Institut Pertanian Bogor* (IPB). SPR is a four-year informal education programme for farmers that aims at welfare creation within

society through participatory learning. The empirical basis of this paper was derived by selecting a "best-case" study (Yin, 2003) of a community of practice composed of cattle farmers in an attempt to examine a culture of rural DIY science in a developing country setting.

The remainder of this paper is structured as follows: in section 2 we present the literature that informs our conceptual framework by exploring concepts of social learning, communities of practice and the relevance of Habermas' theory of communicative action that will assist us in answering our research question. Section 3 discusses the methodological approach that guides the data collection and analysis of the study. In section 4, the analysis and results of the case study will be presented, specifically focusing on the question of how the rural DIY culture has emerged in the context of agricultural farming in a developing country. Section 5 consists of the discussion and conclusion, highlighting the significance of social learning in communities of practice for the cultivation of a DIY science culture in rural societies. Research and practical developmental implications will also be discussed.

2. Conceptual Framework

2.1. Social learning and the Habermasian concept of communicative action

Variations of the term social learning have emerged within the literature over the past decade and have yet to gain a consensus (Muro and Jeffrey, 2008). In a general sense, the term is rooted in behavioural psychology as "casual or directed observation of behaviour performed by others in everyday situation" (Bandura, 1977, p. 39). This implies that learning is regarded as a process in which actors can learn from others in a social context through an iterative feedback loop between the learner and the environment where one affects change in the other simultaneously (Black, 2000, Wals and Van der Leji, 2007). Change as a product of social learning is dependent upon actors' engagement in critical interactions within the social environment (Reed et al., 2010). Whether it is intentional or unintentional, social learning happens naturally in everyday life. While being hereditary in nature, over the years, the role of social learning has become more significant in encouraging, directing or nurturing spaces and processes in which learning is directed towards desired changes.

Although social learning promotes innovation through information generation and diffusion (Newig et al., 2010), it does not always contribute to institutional innovation. Change in social learning is linked to different levels of learning loops; single-loop learning, double-loop learning and triple-loop learning (Eksvard, 2010). The most basic level of single loop learning involves the refinement of actions to leverage performance or in hindsight to do things better. Double-loop learning refers to learning that emphasizes the importance of the underlying assumptions that drive the actions taken by actors. Triple-loop learning implies learning that is rooted in the underlying values, believes and norms that foster actions or perceptions taken by actors. Whilst single loop learning can initiate different courses of actions, societal change can only be effective when it involves the minimum threshold of double loop learning. Within the sector of agriculture, innovations are indicated to be supported by double-loop learning (Dessie et al., 2013, Sol et al., 2013). As such, innovation does not come naturally from farmers as separate individuals, rather it also involves various forms of interaction between farmers and their surrounding communities (Tran et al., 2018). As social change and innovation arise from complex shared processes negotiated by people interacting with ideas, other people and objects (O'Kane et al., 2008), we then refer social learning in this study as a concerted action that results to social change.

Furthermore, we also take the concept of DIY from its prior premise, the "Maker Movement", as an empowerment paradigm of "everyone that operates creative skills to design and make objects, as well as applies peer-to-peer based learning to solve problems" (Ferretti, 2019, p.14). The term "Do-it-

Yourself" implies the act of "making" that is depicted as something that has always existed, it is thus not always dependent on technological aspects, but rather on a cultural mindset (Burke, 2015). As such we posit that innovation should be subjectively explicated based on the researchers' own disposition as their own working definition (Neilsen, 2001). Rather than direct invention creation, effective innovation by farmers can thus be cultivated through a collective or collaborative approach in terms of the adoption of technology, behaviours and attitudes (Lankester, 2013, McKenzie, 2013). Similar to Cross and Ampt (2016), by defining innovators as creators of new forms of knowledge who produce innovative sustainable solutions through the integration of local and scientific knowledge, we believe that all farmers are innovators in their own propensity. We can then refer DIY science in this study as any type of "innovation". More specifically, in the context of agricultural farming groups, we refer rural DIY science as a shared identity of farmers that are able to "undertake on-farm experiments to develop innovative solutions and share relevant information among members" (Anil et al., 2015, p.219).

While social learning serves as a solid foundation to study the different forms of interactions among farmers and actors in developing innovation of DIY science in a double-loop learning system, we believe it is still not sufficient to understand how DIY science is culturally embedded within the rural society. In order to do so, we follow the lead of O'Donnell and Henriksen (2002) and O'Donnell (2003) in incorporating the social theory of Jürgen Habermas (1984), which describes intellectual capital creation as following a human lifeworld of communicative action. But rather than focusing on the creation of intellectual capital, we utilize the communicative action of the lifeworld-in-system of Habermas to understand how culture is embedded and can be reproduced within social learning systems (Wenger, 2000).

The foundations of communicative action in a lifeworld-in-system was introduced by Habermas (1984) in his explanation of capitalist societies through three basic sub-systems; money, power and lifeworld. The underlying goals of these subsystems are in contrast to one another - while the end-means logic of money and power is to achieve efficiency, profit and thus success, the communicative logic of the lifeworld system is to create an understanding within the human environments. Communities of practice can be similarly described as being mainly driven by communicative action as a means of collective understandings. Stocks and flows of "knowing" are viewed as central in generating new ideas and imaginings and then leveraging these into value. Language, culture, communications, dialogue, idea generation, imaginings and knowledge sharing are all key issues in the emerging discourse of communities of practice.

A theoretical guideline is also offered by Habermas (1984) on how to conceptualize life-worlds (refer to Table 1). The horizontal features represent the structural components of a lifeworld system (selves, communities of practice and culture) that correspond to their needs of cultural reproduction, social integration, and socialization (horizontal features) where communicative action is conducted (reaching understanding, coordinating interaction, effecting socialization) and embedded within everyday language and interactions. This paper focuses on the cultural components in Habermas' lifeworld system to explore how the combined theories can elucidate the question of how DIY science is cultivated and disseminated in rural societies, along with design considerations that would support this.

Reproduction process	Structural components		
	Culture	**Community of practice**	**Selves**
Cultural reproduction	Interpretative schemata fit for consensus: valid process of knowing (loss of meaning)	Legitimations (withdrawal of legitimation)	Behaviour patterns effective in learning and development (crisis in orientation and development)
Social integration	Obligations (unsettling of collective identity)	Legitimately ordered interpersonal relations (anomie)	Social membership and ownership (alienation)
Socialisation	Interpretative accomplishments (rupture of tradition)	Motivations for actions that conform to norms (withdrawal of motivation)	Interpretative capabilities and personal identities (psycopathologies)

Table 1. Contours of Habermasian lifeworld-in-system, source and adapted from: O'Donnel & Henriksen (2002, p.95)

2.2. Communities of Practice – brokers, boundaries objects and duality of meaning

Group social learning systems are helpfully reflected in communities of practice (Wenger, 2000). Although not all groups learn, the term "communities of practice" that emerged from the seminal work of Etienne Wenger and Jean Leave (Wenger, 1998) refers to those that do learn and are formed spontaneously. The term was an attempt to construct a differing view on how learning is conceptualized upon. In particular, it questions the assumption of knowledge creation through learning as a "one-way street" linear model from teacher(s) to pupil(s) (Handley et al., 2006). Instead, it suggests that individual learning should be thought of as emergent, involving opportunities to participate in the practices of the community as well as the development of an identity which provides a sense of belonging and commitment. As such, rather than depicting learning as a process of knowledge transfer, communities of practice are associated with the type of learning process that can be described as knowledge sharing and social construction (Morgan, 2011). This shared domain of social values and practices is also regarded as a venue to create a common purpose and identity that can be built overtime (Wenger, 2000). In this sense, "practice" can be defined as an interactional process among members, referring to "knowledge in action" (Lesser and Prusak, 1999). By being a member of a community of practise, a person can also access and contribute to a collective identity that becomes itself an important component of common knowledge or "shared understanding" (Allen, 2000:28), which in turn can be defined as identity signifiers. Practice stimulates the concept of community with its position as a linking and knowledge-sharing mechanism, which also suggests that there are no spatial boundaries taking place (ibid). Therefore, it can be said that the essence of communities of practice consists of only the informal relations between members (Wenger, 2000).

In their most fundamental form, communities of practice are mainly formed through exposures of shared problems and thus creating a common understanding among members, i.e. their shared practices and personal bonds that develop over time. Although communities of practice can exist in many forms (e.g. formal, informal, small or big), the three essential components that enable them to become a stable learning environment remain the same (Oreszczyn et al., 2010). Firstly, "mutual engagement" relates to the relationships and norms around what members do through the process of interaction among them. Secondly, by being part of the community that constantly negotiates meaning, "mutual accountability (among participants) that becomes an integral part of practice" (Wenger, 1998, p. 77-78) will be reached and can be directed at a "joint enterprise". Lastly, by virtue

of being a member of the community, “shared repertoires” are developed as common practices that members adopt through the interaction processes. These practices vary from words, stories, actions and ways of doing things to rituals and concepts that the community have produced.

A point that needs to be addressed is that this research also takes into consideration the fact that communities of practice do not work in isolation. Members of a community of practice interact with different communities and actors whether it be in a historical or current context. This will then affect the process of identity formation of members, identifying “who we are and in which communities of practice we belong and are accepted” (Handley et al., 2006, p. 644) , and the participation of members influences their understanding of themselves. Although communities of practice have been widely used to explore learning as socialization processes and identity constructions (e.g. Morgan, 2011, Anil et al., 2015), studies often solely utilize the three core components mentioned above (mutual engagement, joint enterprise, and shared repertoire). Since this research is interested in examining how a culture of DIY science is cultivated and spread among members of rural farmers, we also would like to include concepts within the discourse of communities of practice, namely: brokers, duality of meaning and boundary objects (1998) that are often neglected within research (Figure 1). This turns our attention to the importance of actors within such innovation system (De Haan and Rotmans, 2017). Brokers are defined by Wenger (1998) as members who introduce new practices within or between communities. In this research, we identify brokers as people who facilitate positive environmental change in rural DIY Science by encouraging new perspectives and practices of farming activities or innovations. Duality of meaning on the other hand constitutes the two elements of participation and reification which represent the continual negotiation of meaning within a community of practice. Participation refers to both the actions and activities that a member engages in with relation to the community. While reification represents the artefacts and processes around which communities negotiate meaning. The product of reification are boundary objects, which consist of both material objects and also symbols of human meaning (Wenger, 1998). It is also important to note that participation and reification are not “two sides of the same coin,” instead they coexist and need to be in balanced to be able to create meaning.

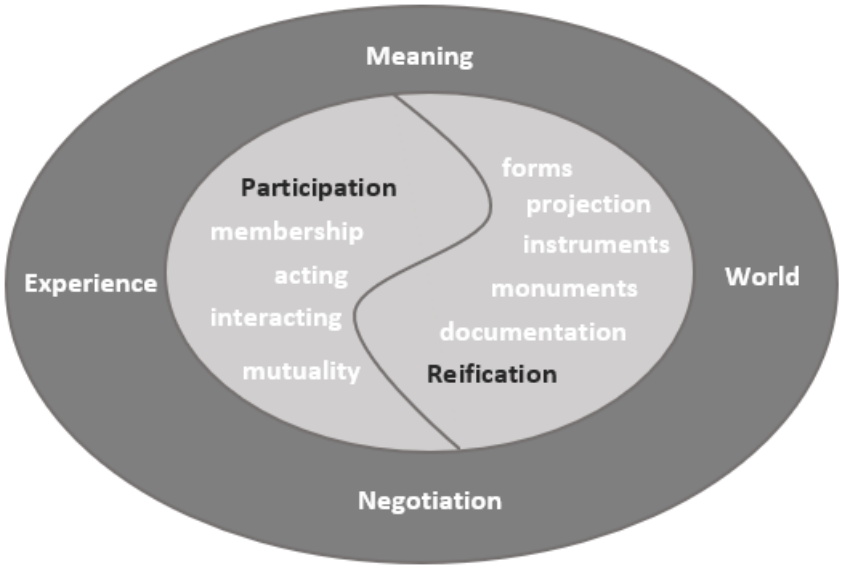

Figure 1. The Duality of participation and reification. Source: Wenger (1998, p.63)

3. Methods

3.1. Case Study

This research focuses on a large-scale project referred to as "*Sekolah Peternakan Rakyat*" or SPR in Indonesia. Being led by "*Institut Pertaninan Bogor*", or the Bogor Institute of Agriculture, as one of the most influential agriculture universities in the country, this programme aims for welfare creation within Indonesian society by educating small-scale farmers through participatory learning for a maximum duration of four years to become independent farmers in running a collectively owned business within the group. Recent data shows that the average educational background of Indonesian farmers is still low; 3,333,279 people attended junior high school or have no education at all, 434,115 people attended high school, 20,943 attended a foundational diploma course and 50,825 attended university (Badan Pusat Statistik, 2018). Due to the fact that the farmers' educational background in Indonesia is still below average, through this participatory learning programme researchers from the university teach, train, assist and guide farmers in terms of both technical and non-technical aspects of agricultural methods on a monthly basis within each region. Owing to the fact that these communities are also constrained in terms of connectivity and resources, Indonesian farmers still prefer to work in a traditional manner, working individually rather than collectively. As such this programme is focused on changing the closed mindset of farmers within this informal learning system that is also aimed at cultivating the idea of "*gotong-royong*", an Indonesian proverb, loosely translated into English as "working together", and in essence also promoting a social learning environment within the society. Between 2013 and 2019, this SPR-IPB programme has been launched in 22 different districts within 10 provinces in Indonesia.

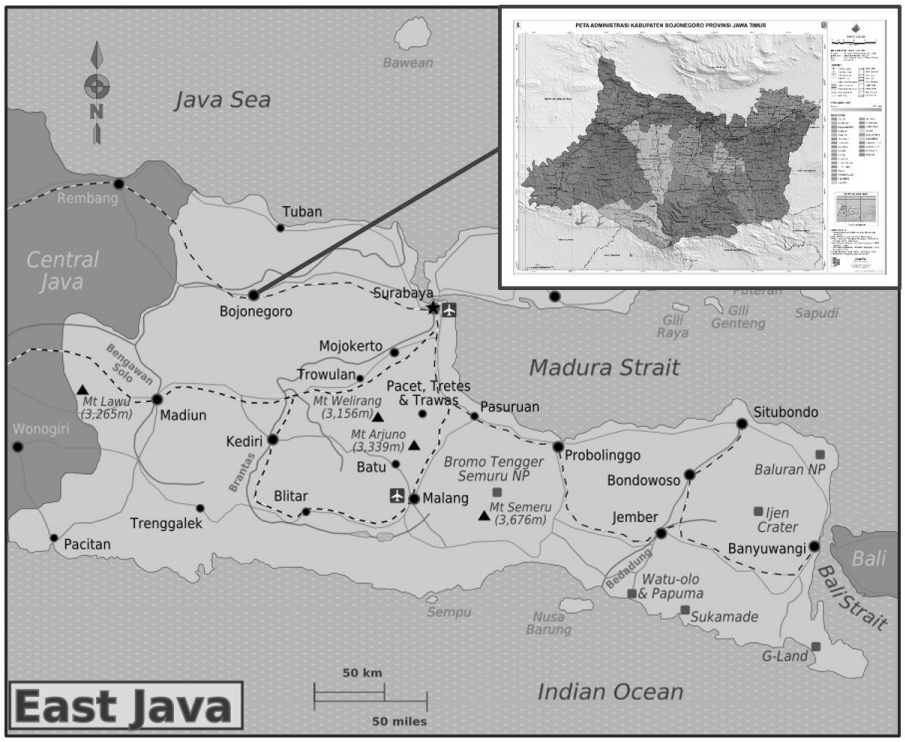

Figure 2. Map of case study area - Kedungadem, Bojonegoro, Indonesia

This study focuses on a rural community cattle farming group that in recent years has emerged as a key player in the Indonesian cattle farming landscape. The case study selected for this study is a group of cattle farming herders in the rural region of Kedungadem, Bojonegoro, located in East Java, Indonesia. This group is situated in one of the few pilot project areas of SPR-IPB, which was initiated in 2014, and they have formally "graduated" from the SPR programme. Bojonegoro has been seen as one of the most deprived regions in Indonesia due to their long history of endemic poverty. Consisting of 235,000 ha of land (40,15% state-owned forest, 32,58% farmland, 22,42% dryland), there are 1.3 million people living in the region. 80% of the population still relies on agriculture as their main source of income. This region is also prone to floods and draughts, resulting in unstable land formation causing poor road conditions. This case study was selected for this research because despite these constraining factors, the cattle farmer group in Kedungadem has emerged as one of the most influential groups in the cattle farming landscape in Indonesia due to their innovativeness in new farming practices. This phenomenon has also been a contributing factor of the region's success in overcoming poverty. Another reason why this specific case study was chosen is the appropriateness of "best case study" (Yin, 2003) to explore the relationships that the farmers have built upon not just among farmers, but also with actors such as the university (IPB), local government and NGOs that have contributed to the emergence of DIY science in this rural community.

3.2. Data Collection and Analysis

Pinpointing our research through Darré's (1991) criteria of interactions, we develop our study around the following elements of interactions between actors (farmers with farmers and farmers with actors across networks) and their sources of knowledge and discourses they produce in relation to their actions and innovativeness. Our unit of analysis thus includes farmers along with their mode of interactions within and outside the community of practice (networks) that links to innovativeness amongst farmers, particularly focusing on innovation that is created within the rural cattle farmer group. A variety of qualitative methods were chosen for this study. We conducted in-depth interviews and focus group discussions (FGDs) with farmers and other agents; observation, document study and informal conversations were also utilized in gathering our data.

Table 2. Summary of interview participants and methods

Methods	Participants	Approaches for data collection and analysis	Data collected
Focus group discussions	3 Focus group discussions with SPR Project team, government officials of Bojonegoro, and with cattle farmer group	Participants were selected based on the participatory approach (Neuman, 2011) Thematic data analysis assisted by NVivo	The nature of Indonesian cattle farming situation and how SPR programme is contributing, rural livelihoods of cattle farmers and the mechanism of learning and knowledge sharing
In-depth interviews	Total of 32 interviews; 5 SPR project leaders, 2 government officials of Bojonegoro, 3 government officials for animal husbandry	Participants were selected based on the FGD and snowball sampling method was also utilized (Liamputtong, 2013)	Policies of cattle farming, impacts of SPR on farmers' learning process, knowledge exchange, networks and

	department, 2 NGO workers, 20 cattle farmers	Naturalistic inquiry of data analysis (Lincoln and Guba, 1985) and thematic analysis (Fereday and Muir-Cochrane, 2006) assisted by NVivo	livelihoods, identification of brokers and boundary object, and adaptation practices of farmers

The data collection process took place within 3 months from August 2019 to October 2019. First, the data collection began with an initial focus group discussion with the SPR project team as well as researchers at IPB and *Lembaga Ilmu Pengetahuan Indonesia* (LIPI), the Indonesian Institute of Science, that are actively involved in the programme implementation. The primary objective of this focus group was to gain a general idea about the Indonesian cattle farming environment prior and after the implementation of the SPR programme, while exploring the suitability of the SPR programme for this research project. This focus group was also helpful in identifying key informants that are playing a crucial role in running the SPR project such as the local government, the animal husbandry department of the local government as well as NGOs. For the purpose of this study, the focus is on a farmers-led group in the East of Java, specifically in the village of Kedungadem, Bojonegoro. This group was chosen based on the focus group discussion and selected as the "best case" study for the successfulness of the SPR programme, which makes it suitable for this study. Particularly, as this research is interested in the question of how a culture of DIY science is cultivated and disseminated within rural society (in this case the group of farmers), an indicator that was taken into account during the selection process was one of the end evaluation criteria made by the SPR programme, namely "*anti kebodohan dan cinta inovasi*", which loosely translates as "anti-ignorance and the love of innovation".

Secondly, a series of in-depth face-to-face interviews with 5 SPR project leaders, 2 government officials of Bojonegoro, 3 government officials of the animal husbandry department in Bojonegoro, 2 NGO workers that were involved in the SPR project and 20 farmer members belonging to the farmer group in Kedungadem, along with site visits and observations, were conducted. The key informants were selected by using purposive and snowball sampling approaches (Liamputtong, 2013). The respondents were identified based on their engagement in the community of practice, in implementing new methods of farming or innovation which we here frame as DIY science, and their empirical understanding of local livelihoods. The interviews lasted between 35 to 65 minutes and were used to gather information regarding how knowledge has been created, utilized and exchanged within the group of farmers and between all actors. As we see innovation as an emerging form of interactions between agents who contribute to the production, exchange and utilization of knowledge, the interviews also involved questions to farmers regarding the role played by each of the other agents (the university – IPB, the local government and NGOs) as well as the interactions within the group that have contributed to their knowledge acquisition and dissemination. These sets of questions helped us to also identify not only the farmers' knowledge networks, but also brokers and boundaries within the community of practice.

All focus group discussions and interviews were recorded, and written notes were also kept. The interview data was transcribed and coded following the naturalistic inquiry of Lincoln and Guba (1985), also grounded in a combination of inductive (data-driven) and deductive (theory-driven) methods to generate themes of the study (Fereday and Muir-Cochrane, 2006). Our analysis also followed the "constant comparative method" between FGDs, interviews, notes, and reflections made

from observations from the field (Alvesson and Sköldberg, 2000). This process has given our analysis detailed insights into emerging themes, foregrounding aspects of social learning, communities of practice and communicative action to study the networks of farming communities through which knowledge is received, conceived and transferred. Moreover, this process allows us to identify the interdependence between brokers and boundary objects, and to explore how the meaning of DIY science (innovation) is constantly being renegotiated among members of the community of practice as a process of cultural reproduction. Summaries of themes that were drawn from our initial inquiry formed the basis of constant comparisons, evaluations and applications of our data analysis. Specifically, we based our analysis on Patterson et al.'s (2011) work on community research that highlights how actors bring about the intangible character of a community through conversational and psychological analytic techniques.

4. Findings

4.1. Community of Practice, a venue for social learning and stimulant for rural DIY Science

This section will pinpoint the relevant dimensions and member characteristics of the selected group of farmers as a community of practice in which social learning occurs, thereby acting as a stimulant for rural DIY Science. Our results suggest that the SPR programme that was initiated within the region has resulted in a community of practice for the cattle farmers in Kedungadem that can be reflected and discussed through the three dimensions that comprise a community of practice. Firstly, in terms of mutual engagement, the group of cattle farmers is bound together as they all share the mutuality of cattle farming as their secondary income. Commonly, the primary source of income or profession mentioned by the interviewees are growing rice, shallots and tobacco plants. Most farmers inherited the land that they use for farming from their family. Cattle farming on the other hand, is seen as a "side job", "side income" or a "hobby" for some. Entry to market was seen as a major constraint and the reason why the majority of farmers does not consider cattle farming as their main income generator. The traditional working style of "individualism" has made it difficult for farmers to market their cattle as most farmers have only small herds at their farms. As such, the primary common ground of the group is to promote cattle farming as a collective effort and their joint enterprise. As this group is one of the pioneering "farmers' associations" within the region, all the members also do not belong to any other farmers group. The group is comprised of two distinct age groups; young farmers and old farmers. The elderly members of the group consist mainly of a former group that was established in the past but did not succeed due to the lack of commitment and understanding among group members. Yet for this new group, farmers have expressed their optimism through phrases such as, "I'm happy being a part of this community", and "knowing that we just started the group not long ago, I think we are doing well".

By the end of the four-year SPR programme the group of cattle farmers reached an agreement to formally create a cooperative organization to officiate their group membership instead of pursuing a collaborative venture. This decision has then led to a greater commitment that strengthened the mutual engagement of the group which is expressed by farmers in individual interviews. For example, in seasons of low crop production, and for the necessity of emergencies, cases of farmers selling their livestock to other channels such as a middleman at lower prices are commonly practiced within the rural region of Kedungadem. Farmers are now committed to supply any amount of livestock that they produce to the group and accept commission fees in an effort to stabilize market prices for every member. Commitment is also shown by other members who are willingly accepting to buy cattle from other members in times of "emergency". Lastly, a shared repertoire has been created by the group as they have monthly meetings to discuss the groups achievements as well as monthly and yearly goals. These meetings are held in a shared communal space that was built for the cooperative. Moreover,

for the organizers of the group, weekly meetings are held every Sunday to ensure the stability of the cooperative.

This community of practice has enabled farmers not only to come together forming a solid association, but it also created a venue for social learning dynamics in varying degrees. Farmers were asked questions about the farming and learning activities before and after the SPR programme had been implemented in the region as well as the benefits that they have reaped throughout the programme. The majority of farmers exhibited individualistic and close-minded characteristics when it came to farming activities. This is emphasized by phrases such as, "I never mind what my neighbours are doing", "we do socialize, but never talk about our jobs", "everyone has their own method of farming". This type of behaviour has also been described as part of an "inherited" culture that is passed down from the elders. This discourse reflects a standard custom that has been practiced throughout generations of farming families before the SPR programme was initiated and thus represents a norm of exclusiveness in one's knowledge acquisition, protecting knowledge as a valuable possession, leaving it unshared with their environment. Individual interviews with farmers revealed that this type of behaviour is not new in the surroundings of Kedungadem. Similar to what is suggested by Klerkx et al. (2010), these practices are a result of the farmers' competitiveness between each other, which is based for example on the assumption that an innovation could lead to better quality of cattle production or first market entry.

As for the aftermath of the SPR programme, our results suggest that there are indications of change with regards to the perception of knowledge, learning and interactions among farmers in the community. Farmers are seen to be more open-minded and willing to learn, developing new perspectives not just on farming activities but also on the benefits that they could reap from working collectively. The forms of learning that are revealed in this study are similar to those of Brown and Schafft's (2011) notion of social interactions, which are not geographically bounded within a single space, in that these interactions also occur outside the boundaries of the community. Firstly, in terms of locality, learning processes occur within the domain of the group of farmers. As they interact regularly on a monthly basis, exchange of experience and knowledge takes place within these meetings as a type of "formal" interaction between farmers. Secondly, as the region of Kedungadem is relatively small, farmers usually gather within the commune for an afternoon tea or coffee break where learning takes place informally in a more casual way. This type of learning is seen as more fruitful compared to the formal gatherings, as expressed by one of the farmers: "usually I don't talk at all in the meetings, I just listen because I am shy. But when we are just hanging around for a break, I feel no tension so I can express myself to my friends". This sense of "shyness" is not uncommon within the group, especially for young farmers that tend to just sit down and observe because of their respect for the elderly. These types of informal learning then provide an opportunity for farmers to establish productive social learning routines among them. Lastly, through the SPR programme, farmers are now exposed to new learning opportunities outside their regional boundaries. The best performing farmers are usually brought by the university to other regions to learn from farms that have implemented new ways of cattle breeding. This then opens not just learning opportunities for farmers, but also new spaces for the innovation discourses of DIY Science.

4.2. Negotiation of meaning of rural DIY Science

4.2.1. Duality of meaning, brokers and boundaries

In this study we identify rural DIY Science as a paradigm of empowerment and as a cultural mindset for farmers. We refer to DIY Science as any type of innovation; in the context of farming groups, it is the ability of farmers in "undertaking on-farm experiments to develop innovative solutions and share relevant information among members" (Anil et al., 2015). In the section above,

we have demonstrated how the community of practice has introduced space in relation to social learning among members. However, in answering our research question of how DIY Science is cultivated within rural societies, we emphasize the importance of external actors, not as agents that directly transfer knowledge, but rather as network expansions of social learning for farmers in negotiating their own meaning of DIY Science[63]. It is found within the research that the farmers' innovations derive from their learning through interactions within and outside the farmers' association, drawing from the wider nexus of social learning (Yoruk, 2019). In the constant negotiation of meaning of DIY Science in the farmers' association, we found that innovation is not self-induced by individual or in-group learning among farmers. Here, we define brokers as someone who facilitates the positive environmental change of introducing DIY Science practices by encouraging new perspectives and practices of farming activities and innovations. As such, in this study we identified what Wenger (1998) refers to as brokers or members who introduce new practices within or between communities of practice.

The hallmark of this particular SPR programme is that it provides a bottom-up approach in providing a venue to farmers where they can learn in a practical and applicative way through collaborating with each other within the community. Compared to state-owned programmes, this approach is not designed to directly provide innovation and technology transfers to farmers. Rather it centres around the notion of "collective" and "interactive" learning which aims to induce farmers' capabilities to think and act independently thus empowering them to be sustainable in their own lives, and can be seen as more of an effort to change the farmers' perceptions and mindset regarding farming and innovation. The difference between state-owned programmes and the SPR programme can be seen in Table 3. From the collected data it is found that this process of changing farmers' perceptions involves various external actors acting as brokers to facilitate the constant negotiation of DIY science in the community.

	Farmers Breeder School (SPR)	**Government led programmes**
Approach	Bottom-up	Top-down
Role of local government	Active	Passive
Budget origin	Local government and other actors (private companies)	Central government
Role of farmers	Interactive	Accommodative
Priority	Education and capacity building for farmers	Provision of facilities and infrastructure

Table 3. Difference between SPR and state programmes

To illustrate this finding, we provide an example of an innovation involving biogas within the farmers' association that demonstrates elements of communities of practice and is a potential leverage for DIY science within the group. A simple yet very useful and highly applicable innovation within rural societies is the usage of livestock waste as an alternative fuel source. Biogas can be used as fuel for each housing unit or farm and the development can be managed together to meet the needs of the farmers' group or even the village. Biogas is considered an applicable alternative for farmers as the materials needed to assemble the structure can be found within household reach. It is found in this study that this form of DIY science is not self-induced by the farmers' own initiative; rather it is a collective effort that was done by several external actors. The initial attempt was made by the university of IPB in their SPR programme. The first step was to visit the village

and, instead of explaining to the farmers what biogas is, to make them aware of their conventional farming practices and how they could be improved with an easy and relatively cheap alternative. However, this is a challenge for a number of reasons. Firstly, the attempt of a university "lecturer" to educate farmers directly, did not seem too effective in getting their attention. In the interviews the farmers mentioned that it was "just odd" for someone to come and teach them something new, a similar observation that was made by Spielman et al. (2011). This describes the sense of isolation of the farmers, who felt abandoned by state services. Secondly, the language and the way of communicating to farmers was perceived as highly sophisticated. Hence some of the farmers voiced their weariness when it comes to attending the meetings. In response to these challenges, the university took the initiative to recruit a "manager" from the region in order to facilitate and motivate farmers in terms of new practices and innovations. In order to ease communication with farmers, this manager developed a poster as a visual tool that explicated biogas in pictures and was intended to reduce the complexity that is implied in the innovation process. During the creation of the poster, farmers also engaged ingroup discussions to come up with a list of their own suggestions and difficulties in terms of biogas innovation. This not only helped the farmers to interact with one another, but also to induce their willingness to express their thoughts. In order to attract the farmers' attention, the poster was intentionally placed in the common area of the farmers' association building. The positive impact can be seen in the farmers' willingness to implement biogas in their homes as well as the commune and in their proactiveness in questioning new methods in meetings to best suit their needs.

Another important contribution is made by the government of Bojonegoro and a local NGO. Firstly, the local government can be seen as an extension of the social learning nexus through their monthly visits to the village and specifically the farmers' association, along with a university member and the manager to introduce new learning materials for farmers. The local government officials have a monitoring role, to ensure the farmers' participation and also to provide hands-on workshops of biogas innovation along with assistance in providing essential farming materials when needed. By developing this bond overtime, farmers are able to engage with local state members in a more dynamic way by exchanging knowledge around farming practices that induces a sense of innovation. Support is also provided by a local NGO that helps to enforce this effort on an on-off basis. However, unlike authors that emphasize the effectiveness of efforts taken by NGOs because of their geographical proximity to a society, it is found in this study that the NGO is not playing a primary role. Whenever the local manager of the farmers' association requires help in terms of technical support, the NGO will assist them in solving the problem. Nevertheless, a type of informal knowledge exchange also occurs within the setting through casual talks between NGO workers and farmers. It was found that farmers are more open when discussing an issue with an NGO worker due to their relaxed way of communicating.

This narrative has demonstrated how external actors are identified as brokers within the farmers' association, acting as mediators in introducing new farming practices that induce the farmers' participation and willingness in negotiating the meaning of DIY science. Apart from what is commonly understood as farming activities, performed according to local standards, farmers are involved in constantly redefining the rules which determine why farming is done one way rather than another. In this process, trust is first established within the social learning nexus, enabling an exchange of perspectives, and knowledge created within the society. Specifically, the programme also demonstrated how a visual tool could act as a boundary object that reified the meaning of such an innovation to engage with rural farmers. Through an iterative process of negotiation, farmers are able to relate their livelihoods to DIY science and create their own meaning of DIY science.

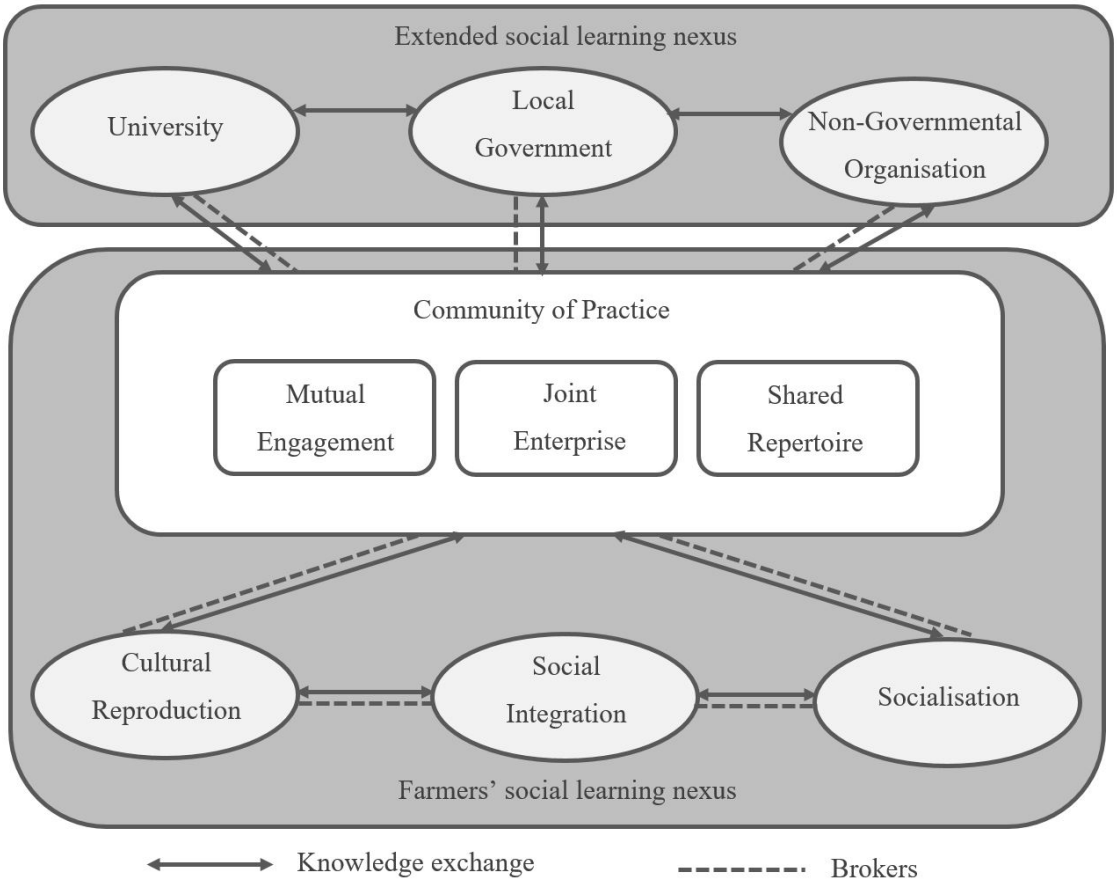

Figure 3. Cultivation of rural DIY science in rural communities

4.2.2. Cultivating a culture of DIY science in rural communities – a Habermasian approach of social construction

In the above section we have discussed how the meaning of DIY science is negotiated within the farmers' association community of practice. We now showcase our findings on how the culture of DIY science is cultivated within the society through outlining the Habermasian communicative action aspects. Communicative action, under the functional aspect of reaching understanding, facilitates the transmission and renewal of cultural knowledge; under the aspect of coordinating action, it facilitates social integration and the establishment of group solidarities; and under the aspect of socialisation, it facilitates the formation of personal and community identities (Habermas, 1987b). Communication with everyday language with communicative relations is inherited in the identity creation of a community. There is however, both a positive and negative impact that can result from these processes in this particular "life-world". Refer to Table 1, which represents the positive and negative impacts of the reproduction process.

The case example above of introducing biogas to rural farmers can be seen as the first step of cultural reproduction. Through the interactions between farmers, local government, NGO and the university, a valid process of acquiring knowledge was built overtime for farmers through communicative action. It introduces the notion of innovation as a type of DIY science in the community of practice. However, this group has struggled to gain recognition within the village

and to create awareness of the importance of innovation in farming practices due to their immature communal identity. This immaturity can be related to the loss of meaning of what the farmers had believed in the past and the routines of old practices that they had utilized throughout the years. Moreover, the farmers' transition from being regarded as "outsiders" when it came to their involvement in technological innovations to having an active role in the decision-making process has created a phase of adjustment among members of the community. Nevertheless, the solidarity of this community was strengthened with the help of external actors who endorsed their position in society, e.g. by pushing them to participate in a regionwide cattle auction. The farmers' association won the award for best cattle award, demonstrating that by experimenting innovation within their farming practices has resulted to various achievements. Through this event, socialization was made as a form of interpretative accomplishment that can be seen by outsiders of the community of practice. The positive impacts can then be seen within the farmers' association as they have built confidence in their identity in terms of innovating farming practices. Socialization can also be demonstrated by the efforts of some farmers that are invited to other villages to teach them how to implement biogas in their community. The recognition of this group is also seen by other farmers from other regions that have come to the farmers' association to join as members.

5. Discussion and Conclusion

Do-It-Yourself (DIY) science has evolved from an expression explaining the art of "crafting" as a social practice (Gelber, 1999) to a term that explicates movements of various self-taught disruptive innovations made in unconventional settings that transform the common practices of research (Ferretti, 2019, Cressey, 2017, Dance, 2017). Although this term has been useful in elucidating movements of what is referred to as "citizen science" (Sleator, 2016a) in fields of high disruption technologies, its usage in other domains, especially in rural context is still absent. Further, by being highly concentrated in advanced technologies and innovations, issues surrounding the discourse of DIY science may not be relevant in other research contexts.

In this paper, we have shown that the applicability of DIY science is more valuable, in terms of its usage, in developing countries where such innovation systems are pivotal for development outcomes. Moreover, in examining DIY science in rural contexts, we also demonstrated that its utilization emphasizes the positive values of innovation and opens up promising avenues of empowerment and welfare creation for the poor. Therefore, the objective of this study was to explore the applicability of DIY science in rural societies, specifically identifying sources of knowledge acquisition and the mechanisms through which it is disseminated that foster an innovative culture of DIY science. Thus, this study investigated a new form of DIY science as a culture that stems from communities of practice (CoP) to alter new modes of innovation thinking within rural societies. In doing do, we utilized a best case study approach (Yin, 2003) which is appropriate for our study given the lack of scientific knowledge regarding the DIY science phenomena in the context of rural societies (Yin, 2009, Eisenhardt, 1989). Our research investigates an early exploratory inquiry concerning the question how rural societies can cultivate a culture of DIY science (Yin, 2009) by examining a group of farmers who have taken part in the SPR project located in the rural region of Bojonegoro, Indonesia. The aim of the programme was to educate farmers through participatory learning, training and assisting them in terms of both technical and non-technical aspects of agricultural methods. The motivation of this collaborative programme was to change the closed-minded mentality of farmers and to cultivate the idea of working together that aims to develop innovation across farming communities that will have a significant effect on their welfare. This farmers' group located in Bojonegoro, one of the initial SPR project participants, which was initiated by *Institut Pertanian Bogor* along with the local government

of Bojonegoro, has showcased initiatives of innovation resulting in various achievements within the cattle farming landscape of Indonesia.

The SPR project created a farming CoP that has indeed provided a venue for social learning for farmers and helped establish a culture of DIY science in this rural context. Through this CoP, farmers have formed informal networks consisting of individuals who share the same propinquity (Rose, 2000), knitted together by innovative farming practices. This has provided an opportunity for farmers to not only acquire knowledge, but also to initiate the preliminary stage of developing a culture of DIY science. Through the focus group discussions and interviews with the SPR project team, government officials of Bojonegoro, NGO workers and farmers have revealed to us the wider networks that exist outside their community of practice. Similar to (Wah et al., 2007) we have found that these interactions between farmers and actors within the wider nexus of the community (university lecturers, NGO workers and government officials) have created joint resources of social capital that are important for knowledge sharing and transfer. The membership of this network can thus also ensure better access to information as well as economic resources (Hoang et al., 2006).

As we take the position that all farmers are essentially innovators and that it is a subjective process to define an innovation; "each researcher must come up with his or her own working definition" (Neilsen, 2001), we define "innovators" as integrators who apply multiple forms of knowledge (including scientific and local) to situations, creating new knowledge and producing sustainable solutions. Although, it should be noted that through our analysis, we found that rural farmers became "innovators" by adapting technologies, techniques, attitudes, and behaviours in collaboration rather than adopting inventions in isolation (Lankester, 2013, Allan and Youdell, 2017). We recognize collaboration and co-creation are key aspects of knowledge generation, a similar perspective to Klerkx & Leeuwis' (2008) "innovation systems".

Furthermore, it is also revealed in our research that the informality of learning that takes place in settings such as afternoon tea or coffee breaks when farmers usually gather within the commune are more effective in terms of "speaking out", overcoming their shyness mentality to achieve a more open-minded community. This finding is also in line with Kilpatrick and Johns (2003) study on the contributors of learning, whereby the community, workplace and even home or informal settings are all equally important sources of learning mechanisms. In addition, this also supports statements of DIY science that reveal how innovations made by rural societies, in our case the farmers, are conducted within informal settings (Ferretti, 2019, Dance, 2017). Although the biogas case example that we showcase in our analysis is not regarded as a highly advanced technological disruption, it is also worth to take note that within rural settings, small incremental innovation ideas have proved to provide a step towards a cascading effect in an effective innovation system. More importantly, by discovering the applicability of biogas innovation within the rural society, farmers are then able to uncover their own meaning of DIY science by constantly negotiating its usage in their own settings. The utilization of concepts related to communities of practice such as brokers and boundary objects have also provided rigour to our analysis by giving evidence of the underlying components in the cultivation of rural DIY science. As indicated by Wenger (1998, p.56), participation within a community of practice involves both actions and connections, "it combines doing, talking, thinking, feeling and belonging", as such the innovation or DIY science competence of farmers is acquired through inclusion of these brokers.

In terms of practical implications, we suggest that in terms of innovation creation in rural settings, the effort of a direct technology transfer is considered ineffective and there is a need of a holistic approach to the system (McIntyre et al., 2009). As we also showcase the usefulness of CoP in the cultivation of a DIY science culture, it is useful for governments and related agencies to consider group learning as

an alternative method of an innovation system for rural communities. Moreover, the wider nexus of the CoP, such as NGOs, governments, universities and other corresponding bodies should also be present in assisting the process of knowledge acquisition and sharing for the community. Having a close linkage with members of the main CoP will also give an advantage of being considered as "insiders" that will give access to comfortable feedback loops for further system improvements. It should also be stressed that at the level of social culture, outside actors (e.g. government, NGOs) should assist the targeted communities by only the facilitation of a cultural context of DIY science innovation. This will then allow space creation for members of the CoP to gradually agree on the boundaries of their own personal meaning of innovation whilst also considering personal and communal needs.

In conclusion, our research has provided new insights into the meaning and applicability of DIY science in the context of rural societies. We hope that the framework and findings of our research contribute to the debate of DIY science, specifically in providing a starting point for the utilization of this concept in other domains. Still, similar to any other empirical research, this study could not be interpreted without any limitations to the research approach. Our single case study has provided an important in-depth starting point in exploring the new and emergent topic of DIY science in rural societies, however, this study only utilized cross-sectional data as opposed to the longitudinal approach. Therefore, the limitations of validity and generalizability should also be considered. As such, it would be helpful for further research to conduct cross-case studies and also use the longitudinal approach to obtain deeper findings and analysis of the study. Consequently, analysis of DIY science in other contexts of rural societies will be especially relevant. Furthermore, other factors which influence whether the results of communities of practice are successful in cultivating DIY science are of special interest.

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