Faculty of Design

2021

Infrastructuring for Social Innovation Inspired by Social Insects

Kim, Sojung and Baek, Joon Sang

Infrastructuring for social innovation inspired by social insects

A research through design method for understanding the nature of social biomimicry

Sojung Kim, Joon Sang Baek
Department of Human Environment and Design, College of Human Ecology,
Yonsei University, South Korea

Infrastructuring has been valued in social innovation sector since it can support collaborations by connecting diverse actors and arranging resources. Setting collaboration as the goal of infrastructuring, we expect the collaborations of animals to be an inspiration for infrastructuring. Such attempts to apply natural principles to human societies are termed social biomimicry, but its practice and methodologies have rarely been studied. This research aims at understanding social biomimicry practice in the context of infrastructuring. To investigate the empirical social biomimicry process from a first person perspective, we employed a research through design (RtD) method. By designing and operating an open collaboration platform inspired by the self-organisation of social insects, we found that social biomimicry has limitations in address the relational and evolutionary aspects of infrastructuring properly. Discussing how such constraints of social biomimicry leads to challenges for designers, we suggest the necessity of methodologies to support designers.

Keywords: Social biomimicry, Infrastructuring, Research through design (RtD), Socio-technical system (STS)

Introduction

The social innovation domain emphasises the significance of infrastructure because they facilitate collaborations by connecting diverse stakeholders and arranging time and resources for group work (Hillgren, Seravalli, & Emilson, 2011). Being perceived to reflect the relationship between people's activities and the technologies supporting those activities (Karasti, 2014), we can consider information infrastructure as a socio-technical system. An STS perspective describes a process that includes technical systems, designed for specific purposes, and social systems, which evolve depending on the external environment and technical systems (Fisher and Herrmann, 2011). Although designers cannot manipulate a social system, they can design a technical system to influence the social one (Baek et al., 2018). From an STS perspective, we redefine infrastructuring for social innovation as designing technical systems to induce collaborative behaviors for social innovation in social system. Setting collaboration as the aim of the social system, this research was motivated by the potential that collaborative animals in nature can provide inspirations for infrastructuring.

Such attempts to apply natural principles to human societies are termed social biomimicry (Holbrook, 2010; Ausubel, 2012; Werntz, 2014; Hunter, 2015; Schieffer and Lessem, 2016). Both social and conventional biomimicry use technical systems as their design objects. They are distinguished in that conventional biomimicry directly applies natural principles to technical systems, whereas social biomimicry indirectly achieves its design purposes by manipulating technical systems, which in turn affect social systems. Studies show the potential of social biomimicry by suggesting that diverse natural principles apply to human organisations (Mars et al., 2012; Baumeister and Herzlich, 2015; Paulraj, 2011; Agarwal and Vrat, 2014; Fewell, 2015). In particular, biomimicry communities for social innovation have focused on how natural systems adapt, communicate, cooperate, self-organise, and build effective networks. They argue that we can learn from natural strategies to transform our culture, drive business growth, and lead an organisation (Biomimicry for Social Innovation, n.d.-a). However, to

the best of our knowledge, little research exists on social biomimicry practice and methodologies (Mead, 2014), which raises the need for the investigation of empirical studies on social biomimicry. Thus, as a complement for the studies in social biomimicry practice, this research addresses the following research questions:

• Question 1: How does the characteristics of design object (infrastructure for social innovation) influence the practical application of social biomimicry?

• Question 2: What are the designers' challenges in social biomimicry practice?

Here, we use a research through design (RtD) method to explore a social biomimicry practice where the self-organisation of social insects is applied to the design of an online platform for crowdsourcing social innovation ideas. RtD helps researchers be more aware of their design activities and obtain the unobservable tacit knowledge and decision-making processes (Pedgley, 2007). To understand the designers' cognitive process and challenges involved in social biomimicry practice from a first person perspective, we designed and operated an open collaboration platform for social problem solving inspired by the self-organization of social insects.

Literature review

Biomimicry for social innovation

Social innovation is 'new ideas (products, services, and models) that simultaneously meet social needs and create new social relationships or collaborations' (Murray et al., 2010, pp. 3). That is, the aim of social innovation is to achieve behavioural changes and social wellbeing, in addition to resolving social problems such as the unavailability of safe drinking water and poverty (Ceschin and Gaziulusoy, 2016). To achieve these aims, social innovation addresses diverse design objects: principles and ideas, services and products, social movements and programmes, organisations and processes, and legislation and policy (Phills, Deiglmeier, and Miller, 2008; Sørensen and Torfing, 2014). Social innovation requires the involvement of diverse stakeholders, including research centres, industrial associations, non-governmental organisations, local administrations, end-users, and policymakers (Ceschin and Gaziulusoy, 2016). Since collaboration has great significance in the social innovation process, new leadership and management is needed to support the collaboration of diverse actors in social innovation (Sørensen and Torfing, 2014). Further, Murray et al. (2010) argued that expanding networks and inviting new participants will augment the drivers of social innovation and overcome organisational constraints and pursue an open and social approach.

The biomimicry community argues that nature, with a 3.8-billion-year history, can inspire the design for social innovation (Phills, Deiglmeier, and Miller, 2008) with features such as sustainability, adaptability, collaboration, mutualism, and networking. There are a few biomimicry tools and methods for social innovators. For example, Life's Principal Leadership Cards, a deck of 52 cards, introduce natural phenomena and inspirational principles for improving leadership (Biomimicry 3.8, n.d.-a). Furthermore, the biomimicry community holds workshops where participants can observe nature and learn about biological cases and biomimicry tools and about how they can apply biological inspirations for improving leadership, management, and organisational capacity (Biomimicry for Social Innovation, n.d.-b). Designers can also find natural cases from Life's Principal Cards (Biomimicry 3.8, n.d.-b) and Asknature (Biomimicry Institute, 2018), which nevertheless were not specifically designed for social innovation. Both include physical, chemical, and technical insights; nevertheless, the cases and principles related to adaption, cooperation, and coordination are applicable to enhancing social capacities. The review of extant biomimicry methodology for social innovation suggests that it introduces inspirational phenomena and natural principles without validation. This is contrasted by biomimicry in the engineering domain where diverse tools and methods have been developed and assessed on academic and systematic approaches (Fayemi et al., 2017).

Infrastructuring for social innovation

Infrastructuring is defined as a 'continuous process of building relations with diverse actors and by a flexible allotment of time and resources' (Hillgren et al., 2011, pp. 180) or 'social constructs with open, dynamic, and heterogeneous structures for participation' (Karasti, 2014, pp. 143). Due to the characteristics of infrastructuring that support engender a long-term trustful collaborative relationship (Hillgren et al., 2011), we argue that collaborative principles in nature can be applied to infrastructuring for social innovation.

Infrastructure has some traits to be considered for designing them. The first trait is the relational aspect. As aforementioned, infrastructure facilitates the relationships among actors, but its development involves intricate relationships as well (Simonsen, 2020). As an object is defined as a tool when it is used for an activity, infrastructure emerges depending on the structures and activities of human practice (Star and Ruhleder, 1996). Accordingly, it reflects the relationships between human organisational methods and the technologies enabling and supporting such practices (Simonsen, 2020). Furthermore, infrastructure has outward connective capacities to plug into external tools and other infrastructure (Simonsen, 2020). Because of these complex relationships, infrastructure is relative rather than absolute to designers' perspectives (Star and Bowker, 2002). One person's infrastructure can be another's design object (Star, 1999; Karasti, 2014); for instance, a crowdsourcing platform may be infrastructure for participants but a product to create and maintain for software developers.

The second trait is the emergent and evolutionary aspect. Infrastructuring is defined as 'the work of creating socio-technical resources that intentionally enable adoption and appropriation beyond the initial scope of the design, a process that might include participants not present during the initial design' (Dantec and DiSalvo, 2013, pp. 247). This implies that infrastructure design should consider dynamic factors – including the number of participants – and respond accordingly. Star and Bowker (2002) claimed that infrastructure can be modifiable at both the individual and social levels; it should allow users to adapt it to their purpose and adjust to changing social needs. However, designing a modifiable infrastructure is difficult because the required flexibilities are usually emergent (Star and Bowker, 2002). Thus, Star and Bowker (2002) stated that infrastructure should be designed through an evolutionary, distributed process rather than a single great design plan or master blueprint. Nevertheless, infrastructure evolution remains a demanding process and requires time and negotiations (Simonsen, 2020).

Research through design

RtD is 'a research approach that employs methods and processes from design practice as a legitimate method of inquiry' (Zimmerman et al., 2010, pp. 310). In this approach, researchers conduct design practice and observe the challenges and processes firsthand (Yang et al., 2019). We could not identify a standardised RtD methodology (Zimmerman et al., 2010), but Bayazit (1993) suggests how to acquire knowledge from design practices as follows:

Knowledge elicitation. This stage involves observing the design domain and data collection, which are then refined or rejected until a satisfactory position is reached following an empirical approach. To acquire expert knowledge, researchers use diverse methods, for instance: (1) examining documentary evidence, (2) obtaining direct information from users and designers, (3) conducting observations while using and creating the design, (4) experimenting with the design and the developed method (prototype), and (5) conducting knowledge and conceptual analysis through calculation techniques using physical and abstract models.

Interpretation of knowledge. The collected data are analysed and interpreted. Diverse types of sensory information including visual, auditory and tactile information is verbalised for analysis. Designers' cognitive processes are often verbalised through reporting methods such as talk aloud or think aloud.

Structuring of knowledge. The knowledge of design activities are structured as a model accurately representing the design process and the concepts relevant to design. While design processes are structured as sequential schema, the structures of other concepts can be described by links, boundaries or part-whole relationship.

Method

In this study, we applied an RtD approach to a social biomimicry project to examine how the traits of infrastructuring influence the social biomimicry practice and what the designers' challenges are. We followed the RtD process proposed by Bayazit (1993) as described in Table 1.

Table 1. Outline of the Research through Design Process

	Knowledge elicitation (Data collection)	Knowledge interpretation (Data analysis)	Structuring of knowledge (Modelling)
Platform design	• Documentation on framework development and platform design • Platform design result	Thematic analysis - Codes and themes - Thematic map	The model describing social biomimicry's scope
Platform implementation	• Documentation on platform operation • Posts and logs made by participants • Interviews with participants		

Outline of social biomimicry project

We designed and ran an open collaboration platform. The platform, titled UVENGERS meaning the avengers in Ulsan, supports crowdsourcing solutions to social problems through collaboration among community members – primarily university students and young adults. We created the online platform inspired by the self-organisation of social insects for open collaboration in the Ulsan province of South Korea, developing a design framework and platform and conducting three social problem-solving projects through it. Figure 1 shows how the project progressed over three years.

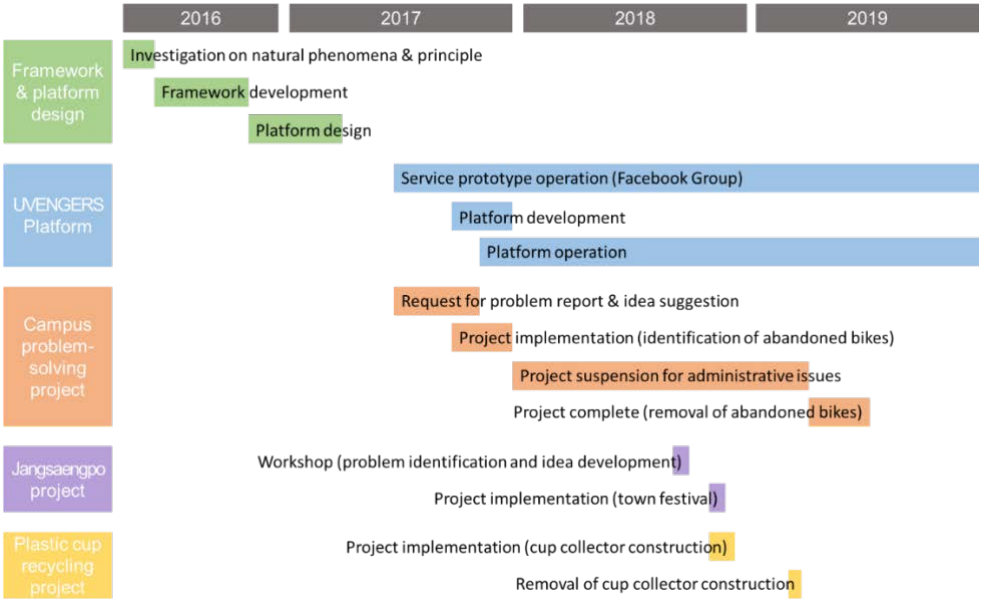

Figure 1. Timeline of the Project

First, we investigated the self-organisation mechanisms of social insects and extracted an underlying principle. This principle explains the reinforcing or balancing feedbacks found in the species' interaction with one another and reaction to the external stimuli. It is through these feedbacks that they can behave as a complex and large system. We used this principle to design a framework for the open collaboration platform (Kim and Baek, 2017). The platform had three menus: problems and ideas, projects, and portfolios (Figure 2). In the problem and ideas menu, users reported social problems that they encountered and shared corresponding solutions. Further, they could support and follow the problems that they were interested in by pushing the 'empathy' buttons. When there were sufficient solutions to a problem, users chose the best solution by voting. Then, the problem was moved to the project menu, where users volunteered to be managers and participants to realise the solution. Next, they executed the project and uploaded their project process on the platform. If they found a project sponsor, the sponsor was acknowledged on the project page. Once a project was complete, it was moved to the portfolio menu. The project pages in this menu could evidence participants' contributions and act as references for future projects.

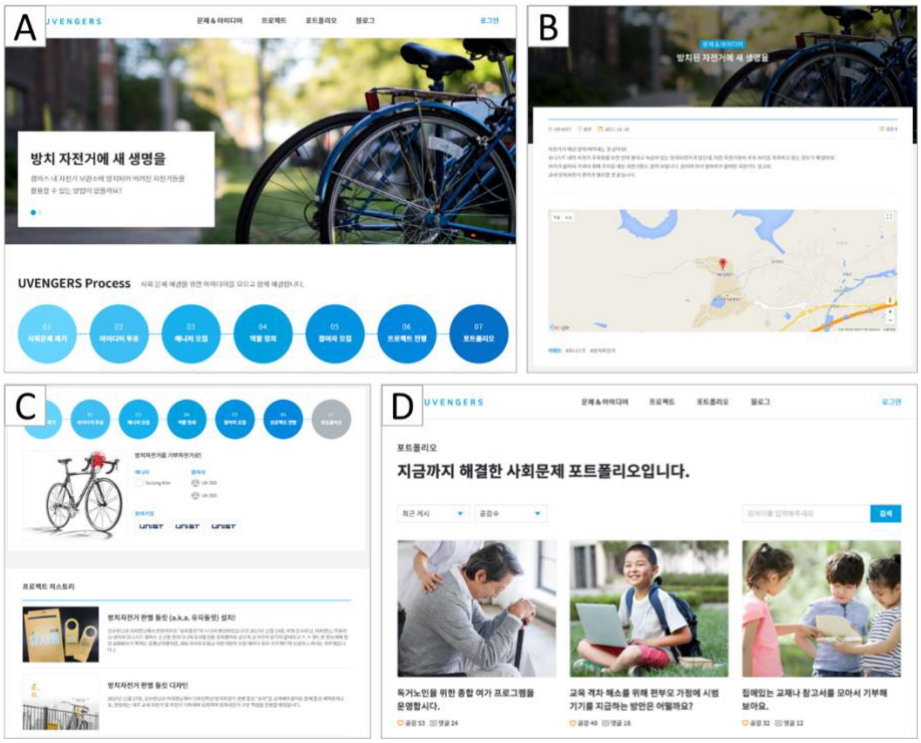

Figure 2. Screenshots of UVENGERS Platform (A: landing page, B: problems & ideas, C; projects, D: portfolios)

While developing the online platform, we began our first project for solving campus problems using Facebook. We collected reports and solution ideas on campus problems from university students and posted the project's progress on the Facebook group. From these reported problems, we ran a project to solve the problem of an abandoned bike (Figure 3, A). After the platform was completed, we transferred the project data from Facebook to the platform and undertook two more projects: revitalising Jangsaengpo village in Ulsan (Figure 3, B) and encouraging plastic cup recycling on campus (Figure 3, C).

Figure 3. The Social Problem-Solving Projects Using the Platform

Data collection

We employed diverse data types. First, we collected documents recorded by us, including the investigation of the self-organisation phenomenon, the descriptions of platform design frameworks, and the UVENGERS platform design as well as our project logs. Second, we collected the Facebook group posts, posts from the UVENGERS platform and other social media, and the communication logs and project-related documents posted by platform users. Finally, we conducted one-on-one and focus group interviews with platform users (Table 2) regarding their experiences and opinions on how the platform could be improved.

Table 2. Interviewee Information

Project	One-on-one interview	Focus group
Campus problem-solving project	1 project manager	-
Jangsaengpo project	2 project managers	6 participants
Plastic cup recycling project	-	1 project manager 2 participants

Data analysis

The research data were analysed using thematic analysis, following Braun and Clarke (2006). First, we organised all documents and interview transcriptions into a data corpus and read it with a colleague. Here, two researchers obtained initial insights from the data and discussed them to reach an agreement on the potential codes, while the main researcher developed a coding scheme with 28 codes. Then, two researchers performed coding according to the coding scheme using the qualitative analysis software NVivo, shared their results, and modified them through further discussion. By doing this, we excluded one code and added two; that is, we obtained 29 codes in total (Table 3). Depending on this final code set, we searched for and named the themes and organised them into a thematic map, including 4 themes and 21 codes.

Table 3. Code List

No.	Code	Description	Final code list	Thematic map
1	Application of natural phenomena	Inspiration from natural phenomena was applied to the framework and platform design.	O	O
2	Application of knowledge of human behaviour and organisation	Knowledge of human behaviour and organisation was applied to the framework and platform design.	O	O
3	Expectations and needs on the platform	The platform was expected to effectively support social problem-solving projects or provide subsidiary benefits.	O	O
4	Platform accessibility	Instead of using a new platform, participants tended to use other familiar social media.	O	O
5	Burden on using the platform	The participants felt it a burden to post on the platform.	O	O
6	Problems in platform usability	Using the platform is complicated and inconvenient.	O	O
7	Platform constraints	Some realistic and environmental conditions restrict the platform's optimum operation.	O	O
8	Project constraints	Some realistic and environmental conditions restrict project progress.	O	O
9	Project participants	Issues exist related to participant groups, e.g., significance of a common understanding and project purpose.	O	
10	Managers	The manager's role involves a high level of participation and burden of responsibility.	O	
11	Stakeholders	Issues exist related to external stakeholders; e.g., differences in position, diverse stakeholders' criteria, and value perception were obstacles to project agreement and decision-making.	O	O
12	Initial inducement of users	Initially, participants were invited via personal contact and on/offline advertisements.	O	
13	Difficulties in inducing participation	Inducing problem reporting and suggesting solutions is difficult; however, inducing participation in practical activities is more difficult.	O	O
14	Specific scope encourages participation	Specified themes or problems increase motivation for participation. Broad topics and ambiguous issues make participants hesitant.	O	
15	Project activities result in positive feedback	Participants' project activities induce the participation of new members.	O	O
16	Impact of projects on communities	The projects were effective in publicising the problems and expanding links to other stakeholders, even though the project output was unsuccessful.	O	O

17	Poor communication	The platform rules and policies, such as managers' duty and the rewards, were not clearly informed.	O	
18	Problems found in platform operation	The problems and requirements found while operating the platform.	O	
19	Necessity of support for the project	The participants faced difficulty in considering diverse stakeholders and anticipating the subsequent effects of the projects.	O	O
20	Necessity of the workshop	Workshops were needed to guide participants in how to effectively use the platform for their projects.	O	O
21	The gap between online platform and offline activities	The use of the online platform was not very active because most project activities were conducted offline.	O	O
22	The gap between platform output and intended purpose	The project portfolio was insufficient as evidence to persuade sponsors.	O	O
23	Limitations of conventional problem-solving methods	The realisation of ideas depends upon the decision-makers of centralised systems and the solutions are usually temporary.	O	O
24	Natural model and open collaboration practice	In reality, the project process was different from the planned linear project process based on a natural model.	O	O
25	Difficulties in open collaboration	Although the platform was designed for open collaboration, the projects were performed in a top-down manner.	O	O
26	Similarity-focused approach	Natural inspiration was adopted as it is similar to open collaboration behaviours, instead of its potential, to overcome the limitations of open collaboration in human societies.	O	
27	Operational strategy according to the life cycle	The platform required running the projects with specified groups in the initial state without abundant users. The projects must be conducted with unspecified individuals once the platform grows and involves enough users.	O	O
28	Importance of realisation	The realisation of ideas is essential to satisfy the needs of participants and reveal the platform's efficacy.	O	
29	Improved cooperation	The participants stated that the platform was helpful for their cooperation.	O	O

Results

Figure 4 shows the thematic map.

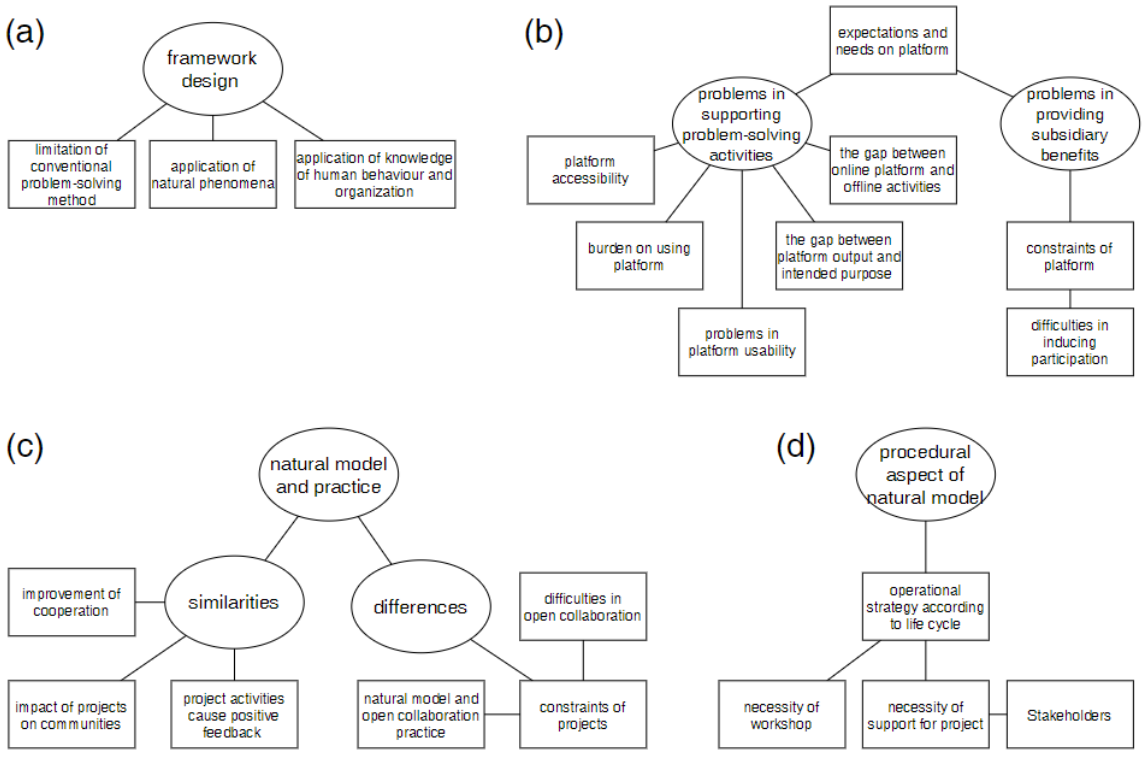

Figure 4. Thematic Map

Theme A: Framework design

The design goal of this project was to facilitate open collaboration for all the stages of the problem-solving process from identifying problems to implementing solution. Designers took the social biomimicry approach, identifying the similarities between the patterns of open collaboration and self-organising behaviour amongst social insects. Generally, inspiration from natural phenomena is translated into a platform design framework's schema. Here, we extracted a natural principle from the self-organising behaviour of social insects: self-organisation enables communities to collaborate and achieve complex, large-scale outcomes through local communication, decision making, and individual actions based on simple rules and the environment. This principle formed a framework with five elements: (a) organisational goals or required tasks and resources, (b) actors, (c) commons, (d) task design, and (e) information communication. Further, we undertook literature reviews on organisational design for open collaboration to identify how each element should be set (Kim and Baek, 2017).

Theme B: Problems in providing values

The participants had two main motivations: interest in the problems and subsidiary benefits (such as proof of extracurricular activities and economic profit). Participants interested in the problems expected the online platform to support their problem-solving activities; specifically, they wanted to share their projects through the platform and get stakeholders' feedback on their solutions. They also wanted the platform to help them acquire human and financial resources by matching them with new colleagues and sponsors. Additionally, they expected the platform to be a more effective tool for the tasks that, up to that point, had been conducted offline. However, the platform could not fulfil those needs because of several limitations. The platform's accessibility was low; therefore, the number of platform users hardly increased, and its impact as a communication media was poor. Participants, therefore, used popular social media services instead to advertise their projects or listen to stakeholders' feedback. They also preferred other familiar social media sites because they felt burden about learning how to use the new platform. Since most project activities were offline, they felt that posting on the platform was an additional task. Platform users noted some usability problems as well. The transition from 'problems and ideas' to 'projects and portfolios' and the process of applying for managers were complicated. Moreover, the text editor was inconvenient to use on mobile phones; thus, participants perceived the platform to be ineffective for its original purpose of raising project funds and participation.

Furthermore, the platform could not satisfy the participants' needs for subsidiary benefits because of operational constraints. From the user research, we found that university students have a strong desire for a certificate of voluntary activity as it is a graduation requirement. However, since we were running this platform as a start-up, we could not issue a certificate. In terms of economic profit, we could not monetarily reward participants since the start-up did not generate revenue. Without these motivating factors, it was difficult to ensure project participation. Some community members reported problems and inconveniences and criticised the project outcomes but hardly suggested any solutions. Recruiting volunteers for projects was even more difficult. For instance, when we held a workshop for the campus problem-solving project, some students shared their ideas and opinions; however, none of the volunteers wanted to participate and take charge of the project tasks.

Theme C: Similarities and differences between the natural model and practice

Implementing the open collaboration platform resulted in user behaviours that were similar to or different from the natural model of self-organisation. Despite the platform's limitations and the difficulties in inviting participants, they responded that the platform helped facilitate collaboration. In the plastic cup recycling project, for instance, the manager reported that after initially designing the cup collector, they revised the design based on feedback from other participants. Moreover, the platform-based activities triggered positive feedback for the self-organisation of community members by drawing their attention to social problems and encouraging their participation. At the beginning of the campus problem-solving project, we held a two-week event on social media to collect campus problem reports. Some student kept posting the problem reports even after the event. The projects' outcomes also involved positive feedback: by experiencing these outcomes, non-participating community members perceived the social problems and supported the projects. Even though some outcomes could not successfully solve the problems, they publicised them and invited potential collaborators. In the plastic cup recycling project, the cup collector could not solve the problem of poor segregation. Nonetheless, the project participants publicised this issue on social media by reporting that students tended to throw the cups without separating the lids, straws and liquid. Thus, students perceived this problem, and some even criticised others who

did not correctly recycle their cups. Furthermore, a student club suggested that the project participants should conduct a campaign to encourage recycling together.

In some ways, the project practices displayed different behaviours from the self-organisation found in nature. The first reason was operational constraints. To complete the projects in a limited time, participants had to take a centralised decision-making approach instead of collective intelligence, which takes more time; moreover, the problems often required the contribution of experts or organisational authority. Accordingly, even though the solutions were derived through collective intelligence, they were implemented depending on a few people with expertise or decision-making power. Consequently, in contrast to the collaboration of unspecified individuals in the natural model, the projects were conducted in a top-down way by the specified participants. Specifically, most participants were managers' acquaintances, and managers tended to dictate the projects' direction rather than facilitate members' participation and collaboration. The plastic cup recycling project had to be completed in a month because of the time limit of the project fund. Hence, the manager omitted communication about the target problem with the stakeholders on campus and conducted the project with predetermined team members and solutions.

Theme D: Procedural aspects of the natural model

Being unfamiliar with the platform and the process of social problem-solving projects, participants claimed that they needed further assistance in using the platform and in conducting projects. Regarding platform usage, participants often misunderstood how to use it as well as their roles and authority while using it. For instance, the manager of a campus problem-solving project did not understand that they could post on the project page, even though we had notified them as soon as they had become managers.

In the Jangsaengpo project, participants did get used to the platform because we taught them how to use it and asked them to post their ideas while using it in the workshop. However, the workshop's scope ranged from problem definition to project planning; therefore, participants were still unfamiliar with the project menu. Furthermore, participants needed additional support for running the projects. They had difficulties in terms of problem-solving methodologies, such as understanding stakeholders, resolving conflicts among them, and facilitating their collaboration. In the plastic cup recycling project, the participants implemented the cup collector without exploring the diverse stakeholders involved in the problem. Consequently, they faced unexpected opposition from the cleaning staff because the cup collector was inconvenient to empty and clean. The Jangsaengpo project's participants also encountered a problem in their project outcomes due to the lack of a collaborative attitude. They designed and produced some local goods to activate a community economy; however, since the designers worked independently without discussion on the products' concepts, their outcomes lost any consistency as a product family.

The Jangsaengpo project's manager claimed that we needed to operate the platform and projects according to the platform's lifecycle: as there were few platform users in the initial phase, we needed to conduct the projects within groups or communities rather than targeting many unspecified people from the beginning. Since the platform was new to them, we needed to guide them on using the platform across the project lifecycle via platform-based workshops, covering the entire process. Then, the users would be able to understand the platform's functions and its effectiveness. After the platform had built a loyal user base and accumulated some successful project cases, we could have invited the participation of sponsor organisations and the public. As the platform's impact increased, the public would be able to report social problems, suggest ideas, and conduct projects in a self-organised manner. This strategy could be effective for resolving the current challenges – lack of users, platform unfamiliarity, and top-down operation of projects – in the platform and achieving open collaboration in the long run.

Discussion

The traits of infrastructuring and social biomimicry practice

In this study, we applied social insects' self-organisation mechanisms to designing an open collaboration platform. This is equivalent to infrastructure for social innovation. We found that the scope of our social biomimicry approach could not address the relational and evolutionary aspects of infrastructuring properly.

The first limitation in scope was to disregard the organisation's external environment, which refers to 'everything outside an organisation's boundaries that might affect it' (Griffin, 2016, pp. 67). It comprises the task environment, including aspects such as the regulators, customers, suppliers, competitors, and strategic partners, apart from the general environment, comprising technological, economic, politico-legal, sociocultural, and international dimensions (Griffin, 2016). Such aspects influenced the operation of UVENGERS and the projects; for example, for-profit organisations, including start-ups, are regulated, and they cannot apply for the authority to issue certificates for voluntary activities (Theme B). This factor in the political-legal environment influenced our strategy to encourage user participation. Furthermore, the project period was influenced by the project sponsor, equivalent to a supplier, that resulted in a top-down approach to rapidly complete the project (Theme C). Although these external organisational environmental factors are important for the platform's operation and the projects, they were not significantly addressed in the platform design framework. Consequently, insufficiently considering the external environment presents an obstacle to self-organisation and open collaboration.

Another issue was the failure to consider the procedural aspects of infrastructure development. We developed the platform design framework by gaining inspiration from social insects, which demonstrate innate habits or motivated behaviours such as pheromone emission or bee-dancing (Theme A). Thus, the framework modelled a platform mechanism in a mature state, whereby users were already motivated to post on the platform and press the 'like' buttons. The platform design's developmental process was not covered by the framework; however, in reality, platform value depends on the number of users since they are unwilling to use a platform without a critical mass (Salminen, 2014). Because the UVENGERS platform did not achieve critical mass, participants did not use it to communicate with members or promote their projects (Theme B). To achieve success, apart from having a critical mass, a platform must establish the correct strategy at every stage of the growth process (Kim and Yoo, 2019). Procedural aspects also needed to be addressed as one project manager observed the need to adjust the platform's operational strategies according to its lifecycle (Theme D).

Challenges in social biomimicry

The case study demonstrated that the scope of social biomimicry for infrastructure design is missing details regarding the organisation's external environment and developmental procedure. However, nature's ecological hierarchy and evolutionary processes imply that these gaps originate from the constraints of the social biomimicry approach instead of the natural ecosystem's characteristics.

Social biomimicry for infrastructure design attempts to establish conditions or environments where actors can build relations and collaborate. As each individual's behaviour, groups, organisations, and the environment are interrelated (Mullins, 2010), these dimensions must be considered to facilitate actor collaboration while designing infrastructure. As a human organisation has hierarchical dimensions, a biological organisation also involves several interconnected levels of scale: individual living organisms, populations, communities, ecosystems, and the biosphere (Van As, 2012). We can intervene, to some degree, in both biological and human organisations by, for example, farming or developing platforms. However, both organisational types include factors that are difficult to manipulate, such as the regional climate and cultural tendencies. Because of such uncontrollable environmental factors and the interactions amongst different organisational levels, we often fail to implement the intended interventions or cause an unintended effect.

Developmental processes are observable in both human and biological organisations; as human organisations undergo developmental processes (Greiner, 1998; Kim and Yoo, 2019), biological organisations also evolve. Evolution in nature operates at the genetic, organismal, and population levels, and it involves natural selection, which happens as a specific feature of entities and affects their survivability (Hall and Hallgrímsson, 2011). Particularly, living creatures' behaviours evolve through complex interactions amongst genetic information, physiological processes, and environmental factors (Papini, 2010). For instance, in the evolution of social behaviours, the social context and/or the environment affects organisms' behaviours and their genetic information. Conversely, genetic traits can also modify the social environment by making organisms prefer specific social conditions (Sokolowski and Levine, 2010). This theoretical knowledge of evolution demonstrates that social insects' self-organisation emerged from changes at the genetic, organismal, and population levels rather than merely from interactions among the features of individual entities and environments. As the biological organisation demonstrates, we infer that human self-organisation requires the developmental process to include changes and interactions amongst different organisational levels.

Although both human and biological organisations are hierarchical and go through an evolutionary process, social biomimicry has limitations on the scope of observation and application. For example, we can only observe

the mature state of the self-organisation phenomena in a social insect population and apply this principle to platform design in a mature open organisation (Figure 5).

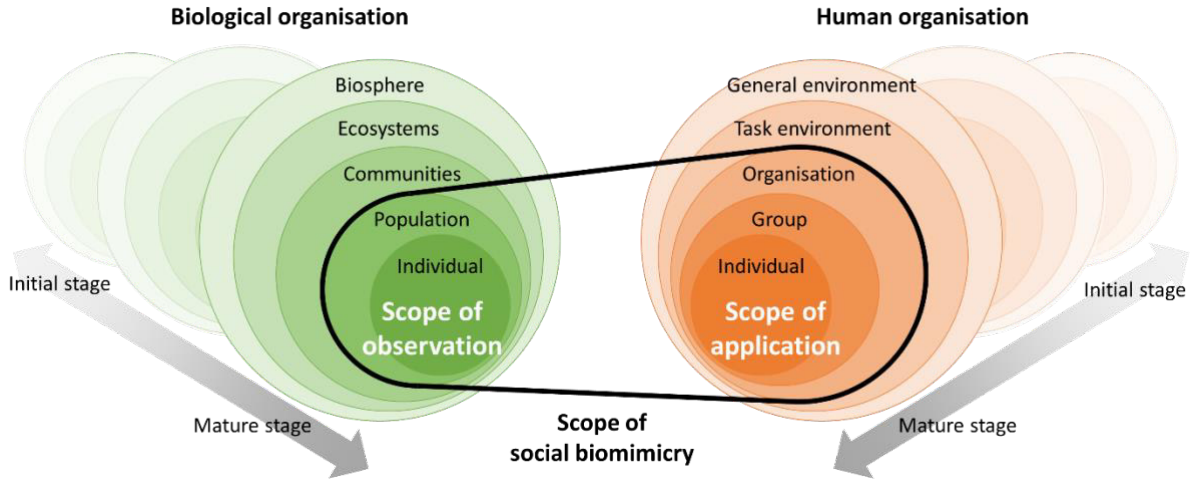

Figure 5. The Model Describing the Scope of Social Biomimicry

It is impossible to overcome the constraints in the social biomimicry approach completely as all factors cannot be considered in all hierarchical dimensions of both biological and human organisations. Furthermore, we have limited understanding of how social behaviours evolve in non-human animals. Under these constraints, we must examine whether social biomimicry approaches are still acceptable if the aim is not to closely imitate natural phenomena but only to gain inspiration from them. Buraczynski (2013) states that biomimicry for architecture does not perfectly reproduce natural phenomena, and due to ecosystem interactions, its effects can differ from the design intention. The issue is that biomimetic architecture is usually directly applied to the real-life environment without thorough testing; even if tests are conducted, long-term effects on human health, society, and the ecosystem may occur, that are yet to be identified. Regarding the long-term influences of design outcomes complex interactions with actors and external environments, social biomimicry adopts a similar position to biomimicry for architecture. This considers designers' 'responsibility to filter nature knowledge and adjust it' to the design space (Cohen and Reich, 2016, pp. 16) and the impact of design outcomes on human societies. Social biomimicry should adopt a more cautious approach instead of recommending natural phenomena as inspirational sources. We propose that social biomimicry methodologies support designers in being aware of the limitations in the scope of social biomimicry and guide them to overcome such limitations using their expertise related to design objects.

Conclusion

This study investigated social biomimicry practice in the context of infrastructuring using an RtD approach. The findings showed that the social biomimicry lens is limited in considering the external environment and the developmental procedure of organisations. In reality, it is not possible to consider all hierarchical and procedural factors. Nevertheless, the potential impact of its outcomes implies that limiting social biomimicry to gaining inspiration from nature cannot justify those limitations; accordingly, we suggest that these methodologies must support designers in addressing the limitations of the scope of social biomimicry itself.

As this study is based on a single case and an RtD approach, one must be cautious in generalising our results. However, this study is meaningful as a pioneering attempt to gain insight into social biomimicry traits through empirical research. We call for further studies on social biomimicry practice to improve our understanding of social biomimicry traits and accumulate empirical evidence regarding its efficiency. In addition, the empirical evidence should lead to further research on developing the methodology.

References

Agarwal, A., & Vrat, P. (2014). Bio inspired managerial insights for a flexible and efficient organization: A SAP–LAP analysis. *Global Journal of Flexible Systems Management, 15*(4), 345-361.

Ausubel, K. (2012). *Dreaming the future: Reimagining civilization in the age of nature:* Chelsea Green Publishing.

Baek, J. S., Kim, S., Pahk, Y., & Manzini, E. (2018). A sociotechnical framework for the design of collaborative services. *Design Studies*, 55, 54-78.

Baumeister, D., & Herzlich, T. (2015). Why the Most Exciting Ideas in Leadership Are Coming From the Forest.

Bayazit, N. (1993). Designing: design knowledge: design research: related sciences *Design methodology and relationships with science* (pp. 121-136): Springer.

Biomimicry 3.8. (n.d.-a). Life's Principles Leadership Cards. Retrieved 20 May, 2020, from https://biomimicry.net/product/lp-leadership-cards/

Biomimicry 3.8. (n.d.-b). Life's Principles Play Deck. Retrieved 20 May, 2020, from https://biomimicry.net/product/lifes-principles-cards/

Biomimicry for Social Innovation. (n.d.-a). Biomimicry for Social Innovation. Retrieved May 20, 2020, from https://bio-sis.net/

Biomimicry for Social Innovation. (n.d.-b). WORKSHOPS & SERVICES. Retrieved 20 May, 2020, from https://bio-sis.net/offerings-and-services-2/

Biomimicry Institute. (2018). AskNature. Retrieved 20 May, 2020, from https://asknature.org/

Buraczynski, K. (2013). The Limitations of Biomimetic Architecture. Retrieved 20 May, 2020, from https://scalar.usc.edu/works/the-limitations-of-biomimetic-architecture/index

Ceschin, F., & Gaziulusoy, I. (2016). Evolution of design for sustainability: From product design to design for system innovations and transitions. *Design Studies*, 47, 118-163.

Cohen, Y. H., & Reich, Y. (2016). The Biomimicry Design Process: Characteristics, Stages and Main Challenge *Biomimetic Design Method for Innovation and Sustainability* (pp. 19-29): Springer.

Dantec, C. A. L., & DiSalvo, C. (2013). Infrastructuring and the formation of publics in participatory design. *Social Studies of Science*, 43(2), 241-264.

Fayemi, P.-E., Wanieck, K., Zollfrank, C., Maranzana, N., & Aoussat, A. (2017). Biomimetics: process, tools and practice. Bioinspiration & biomimetics, 12(1), 011002.

Fewell, J. H. (2015). Social Biomimicry: what do ants and bees tell us about organization in the natural world? *Journal of Bioeconomics*, 17(3), 207-216.

Fischer, G., & Herrmann, T. (2011). Socio-technical systems: a meta-design perspective. *International Journal of Sociotechnology and Knowledge Development (IJSKD)*, 3(1), 1-33.

Greiner, L. E. (1998). Evolution and revolution as organizations grow. *Harvard business review*, 76(3), 55-64.

Griffin, R. W. (2016). *Management*: Cengage Learning.

Hall, B. K., & Hallgrímsson, B. (2007). *Strickberger's Evolution*: Jones & Bartlett Learning, LLC.

Hillgren, P.-A., Seravalli, A., & Emilson, A. (2011). Prototyping and infrastructuring in design for social innovation. *CoDesign*, 7(3-4), 169-183.

Holbrook, C. T., Clark, R. M., Moore, D., Overson, R. P., Penick, C. A., & Smith, A. A. (2010). Social insects inspire human design. *Biology letters*, rsbl20100270.

Hunter, S. T. (2015). Commentary on Chapter 16: Insect Creativity as Applied to Human Organizational Behavior: A Form of Social Biomimicry? *Animal Creativity and Innovation* (pp. 478-482): Elsevier Inc.

Karasti, H. (2014). *Infrastructuring in participatory design*. Paper presented at the Proceedings of the 13th Participatory Design Conference: Research Papers-Volume 1.

Kim, J., & Yoo, J. (2019). Platform Growth Model: The Four Stages of Growth Model. *Sustainability*, 11(20), 5562.

Kim, S., & Baek, J. S. (2017). *Nature-inspired organizational design framework for open collaboration platform development*. Paper presented at the International Association of Societies of Design Research 2017 Conference, Cincinnati, US.

Mars, M. M., Bronstein, J. L., & Lusch, R. F. (2012). The value of a metaphor: Organizations and ecosystems. *Organizational Dynamics*, 41(4), 271-280.

Mead, T. L. (2014). *Biologically-inspired management innovations*. Paper presented at the 2014 International Society for Professional Innovation Management (ISPIM) Conference, Dublin, Ireland.

Mullins, L. J. (2010). *Management and Organisational Behaviour*: Financial Times Prentice Hall.

Murray, R., Caulier-Grice, J., & Mulgan, G. (2010). *The open book of social innovation*: National endowment for science, technology and the art London.

Papini, M. R. (2010). *Comparative psychology: Evolution and development of behavior*: Psychology Press.

Paulraj, S. (2011). Symbiotic Plant-Ant Mutualism: Biomimetics ideas for Outsourcing in Biz Management. *ZOO'S PRINT*, 26(4), 24-26.

Pedgley, O. (2007). Capturing and analysing own design activity. *Design Studies*, 28(5), 463-483.

Phills, J. A., Deiglmeier, K., & Miller, D. T. (2008). Rediscovering social innovation. *Stanford Social Innovation Review*, 6(4), 34-43.

Sørensen, E., & Torfing, J. (2013). Enhancing social innovation by rethinking collaboration, leadership and public governance. *NESTA Social Frontiers*.

Salminen, J. (2014). *Startup dilemmas—strategic problems of early-stage platforms on the Internet*. Turku: Publications of Turku School of Economics, Series A.

Schieffer, A., & Lessem, R. (2016). *Integral development: Realising the transformative potential of individuals, Organisations and societies*: Routledge.

Simonsen, J., Karasti, H., & Hertzum, M. (2020). Infrastructuring and Participatory Design: Exploring infrastructural inversion as analytic, empirical and generative. *Computer Supported Cooperative Work (CSCW)*, 29(1), 115-151.

Sokolowski, M. B., & Levine, J. D. (2010). Nature–nurture interactions. In A. J. Moore, J. Komdeur & T. Székely (Eds.), *Social Behaviour: Genes, Ecology and Evolution* (pp. 11-25). Cambridge: Cambridge University Press.

Star, S. L. (1999). The ethnography of infrastructure. *American Behavioral Scientist*, 43(3), 377-391.

Star, S. L., & Bowker, G. C. (2006). How to infrastructure. *Handbook of new media: Social shaping and social consequences of ICTs*, 230-245.

Star, S. L., & Ruhleder, K. (1996). Steps toward an ecology of infrastructure: Design and access for large information spaces. *Information systems research*, 7(1), 111-134.

van As, J. (2012). *The Story of Life & the Environment*: Penguin Random House South Africa.

Werntz, K. M. (2014). Watching apes could help make humans behave more sustainably, *The Guardian*. Retrieved from https://www.theguardian.com/sustainable-business/behavioural-insights/2014/sep/04/watching-apes-humans-behave-sustainably-social-biomimicry

Yang, Q., Cranshaw, J., Amershi, S., Iqbal, S. T., & Teevan, J. (2019). *Sketching NLP: A Case Study of Exploring the Right Things To Design with Language Intelligence*. Paper presented at the Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems.

Zimmerman, J., Stolterman, E., & Forlizzi, J. (2010). *An analysis and critique of Research through Design: towards a formalization of a research approach*. Paper presented at the proceedings of the 8th ACM conference on designing interactive systems.