Innovation Compass: Integrated System to Support Creativity in Both Individuals and Groups

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Abstract. This study intends to present the concept of a mechanism that will lead to generate active innovations that can change our society. We first analyze the general process of innovations and identify core elements that lead to innovations. We then analyze existing tools and systems that support the creation of innovations in relation to core elements. This analysis leads to the building of the innovation model. We propose an "innovation compass" based on the innovation model that is an integrative system that enhances human creativity to generate innovations. It supports both individual and group creativity. It not only supports rational aspects of innovation processes but also stimulates the motivation of innovators.

Keywords: Innovation · Creative support · Serendipity · Network · Motivation

1 Introduction

The ICT industry is evolving daily with a core focus on business and its use of the Internet. The ICT industry to date has used advanced technology to create high performance, high quality products, and we can expect it to solve various social problems while providing new products and services. However, we must be careful of how capabilities are applied to the market and environmental changes. In other words, companies must create new customer value with a continual understanding of market changes. Drucker asserted that, in "management", the objective of companies is "customer creation" [1]. He also said that in a constantly changing society, companies must continually create new customers. This requires innovation.

The essence of innovation does not simply mean technical innovation, but includes the idea of continuing to create innovative products and services that provide societal value. This is not accomplished through machines but through the creativity of human beings. There are demands for systems that will increase human creativity for people to be imaginative and produce new things. However, most support systems until now have not been distributed to the developers and engineers for whom they were designed. It is difficult to comprehensively and expansively support creativity. Thus, we propose a system to support human creativity that focuses on value creation in this study.

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Section 2, analyzes the elements and processes necessary for creating new values, confirms how these elements and processes are attained in existing systems, and reviews their issues. Section 3, proposes an "innovation compass", which is a support system for human creativity. This is a system for comprehensively supporting both individual and group creativity. Section 4 concludes the paper.

2 Innovation Model

Innovation, as it is used in this paper, is defined as "creating new value and generating change that contributes to society". However, because the solving of immediate problems is the basis of innovation, we have not excluded activities for everyday improvements. Thus, we will first analyze the necessary elements and processes to achieve innovation by considering the creativity support system we propose.

2.1 Necessary Elements and Processes to Achieve Innovation

Many innovation models have been presented in the past, and the requisite elements and processes presented in them have been critical to achieve innovation. We will first analyze these elements and processes, and clarify the types of models we should build. In doing so, we will examine what have been identified as ten representative models [2−11] for generating innovation, thoughts, discoveries, and ideas.

The first involves the ten items required for discovery as noted by Nobel laureate (chemistry) Eiichi Negishi in "Hakken to ha Nanika" (What Is Discovery?) [2]. These ten items are desire, needs, planning, systematic exploration, knowledge, ideas, judgment, willpower, optimism, and serendipity. These indicate what is required for discovery, based on the things that have been deemed necessary over many years of individual research. Of note is that these items have aspects of emotion and behavior, and not simply intellect.

The second model is "Innovation: The Five Disciplines For Creating What Customers Want" [3]. This article is a compilation from the results of consultation conducted by Stanford Research Institute (SRI) International at various corporations. The five disciplines referred to in the title are important needs, value creation, innovation champions, innovation teams, and organizational alignment. Because this article was written within the context of corporate consulting, the focus is on organizations and teams, as well as the roles of leaders. In terms of value creation, it is characteristic in its assertion that success is accomplished through the use of tools.

The third model of innovation is proposed in "Where Good Ideas Come From" [4], which is a publication that considers innovation from an ecological standpoint. The seven laws noted therein are the adjacently possible, liquid networks, the slow hunch, serendipity, error, exaptation, and platforms. This article has a particular focus on the environment in which innovation occurs. In particular, it notes that making connections requires fluidity, noise, and mistakes, and that platforms are necessary for generating creativity.

The fourth model of innovation is "The Innovator's DNA" [5]. This article discusses the five skills of innovators, viz., associating, questioning, observing, networking, and experimenting. In particular, it emphasizes the importance of finding connections between things that appear to be unrelated, and the necessity for interacting with various types of people. In addition, it asserts the necessity for experimentation.

The fifth representative model comes from "Managing Flow: The dynamic theory of knowledge-based firm" [6], which suggests that companies creating knowledge use the socialization, externalization, combination, and internalization (SECI) process [7] to generate output. This output is comprised of following items: values, ba (it is a place for knowledge creation), dialogue, dynamic knowledge assets, and leadership. In particular, this article asserts that when one feels as if one is contributing to society through one's actions, that individual then demonstrates capabilities. In doing so, a dialog with one's companions, and understanding and accepting different ways of thinking become important.

A sixth model is the four-fold "SECI Model" [7]. Of these four, explicit knowledge and tacit knowledge work hand-in-hand in moving forward spirally, which causes new knowledge to be formed in both individuals and organizations.

A seventh model is found in "Theory U" [8], which states that focusing on people's interiority leads to an understanding of future prospects and actions. The five steps in this theory are co-initiating, co-sensing, presencing (connecting to the source of inspiration and will), co-creating, and co-evolving. The article suggests that inner wisdom is found through creating a common will, observing, and listening. This process leads to prototypes and the creation of new products.

The eighth model is the "Introduction to Design Thinking Process Guide" [9], published by The Hasso Plattner Institute of Design at Stanford. Five key steps are outlined: empathize, define, ideate, prototype, and test. According to this guide, understanding users and defining the essence of issues is critical to innovation. The guide also advocates user feedback is obtained on what has been created to further improve the product.

The ninth model is the "W-gata Mondai Kaiketsu Model" ("W-shaped problem-solving Methodology") [10] presented in Jiro Kawakita's "Hasso-Ho" ("Creative thinking method") in which exploration is equivalent to problem-solving, and thought levels and experience levels progress along a W-shaped curve. Determination is made as to whether problems can be solved by exploration, observation, generation of hypotheses, or adoption of hypotheses. The KJ-method suggested in this article is Kawakita Jiro's creative thinking method and most popular problem-solving methodology in Japan.

The tenth model is found in "A Technique for Producing Ideas" [11] by Young, which presents the process of individual idea creation. It states that "ideas are new combinations of old elements", and divides the process into five steps of gathering materials, masticating materials, an incubating stage, the birth of an idea, and shaping and development of the idea.

2.2 Analysis of Innovation Mode

Elements Necessary for Innovation. We reviewed elements and processes necessary to achieve innovation from the surveyed content above (Table 1). Of these items, the following five stand out as being common, i.e., "network", "motivation", "idea creation", "action and practice", and "needs".

Table 1. Necessary analysis of elements for innovation.

Item	Element / Case	Network	Motivation	Idea Creation	Action and practice	Needs
1	Negishi Eiichi, The ten items required for discovery [2]	—	・Desire ・Will power	・Serendipity, ・Idea, ・Knowledge, ・Judgment ・Systematic exploration	・Optimism ・Plan	Needs
2	Innovation: The five disciplines for creating what customers want [3]	Innovation teams	Organizational alignment	Value creation	Innovation champions	Important needs
3	Where good ideas come from: The natural history of innovation [4]	・Exaptation ・Liquid Networks ・Platforms	—	・Serendipity, ・Error, ・The Slow Hunch ・The Adjacent Possible	—	—
4	The Innovator's DNA: Mastering the five skills of disruptive innovators [5]	Networking	Questioning	・Associating ・Observing	Experimenting	—
5	Flow Management: The dynamic theory of knowledge-based firm [6]	・Ba	・Dynamic knowledge assets	・Value ・Dialogue	Leadership	—
6	The knowledge-creating company: How Japanese companies create the dynamics of innovation [7]	—	・Socialization ・Internalization	Externalization	Combination	—
7	Theory U: Learning from the future as it emerges [8]	—	・Co-Initiating ・Co-Sensing ・Co-Evolving	Presencing	Co-creating	—
8	An introduction to design thinking process guide [9]	—	・Empathize ・Define	Ideate	・Prototype ・Test	—
9	Hasso-Ho (Creative thinking methods) [10]	—	—	・Exploration ・Observation ・Hypothesis generation ・Inference	・Plan ・Observation ・Verification	—
10	A technique for producing ideas: Advertising age classics library [11]	—	—	・Gathering materials ・Masticating materials ・Incubating stage ・Birth of idea	Shaping and development of idea	—

Of particular importance to fulfil market "needs" is "idea creation", which requires the interaction of various people who serve as a "network". Further, members must have a common "desire" in regard to their purpose, which is tied to social significance and a sense of mission, and is the source of everything. Generating results requires "motivation" and "action and practice", even though "motivation" is important for continuing to strive for success without giving up. In particular, motivation can be thought of as being both extrinsic and intrinsic. Intrinsic motivation involves relationships with others, leverages one's own capabilities, and develops according to one's own decisions. Conversely, extrinsic motivation is based on monetary or other forms of remuneration. It has been noted that intrinsic motivation is more important than extrinsic motivation for improving intellectually creative activities.

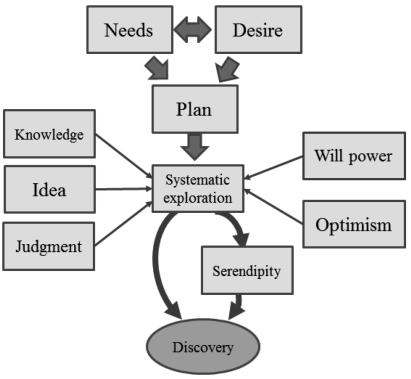
Innovation Processes. We next conducted process-oriented analysis. The corresponding processes are listed in 1 [2] and items 6 to 10 [7−11] in Table 1. Figure 1 compares these innovation processes. Of these processes, "sympathy", "creation", "practice", and "succession" stand out as being four common steps. As can be seen in Table 2, all individuals (1) have feelings that are "sympathetic" to other members and identify the "root of the problem", and in (2), creation occurs. After a prototype is created that is (3) "evaluated and tested", followed by "feedback" as part of "action and practice". The individuals then (4) "inherit" assets that have been created, and use them to solve the next issue. In step 2) of creation, the analysis of items 1, 9, and 10 result in further subdivisions of "problem institution", "gathering information", "serendipity", and "judgment/decision". These are all elements required for individual idea creation.

Innovation Model. Figure 2 outlines an innovation model that provides a comprehensive overview of these elements, and which is comprised of the four steps of "sympathy", "creation", "practice", and "succession". The step of "creation" is further subdivided into "problem institution", "information gathering", "serendipity", and "judgment/decision". Not included in this model from a process standpoint are "network" and "motivation", which are both collaborative in nature, and are thought to be necessary to the overall innovation process. A network is required to generate diverse ideas, through encounters between new people and information, followed by the sharing and exchange of information through connections with groups or other individuals. Motivation impacts will and behavior, as it is the driving force behind processes. Innovation can be enhanced and scaled even for very demanding problems by driving and expanding the process.

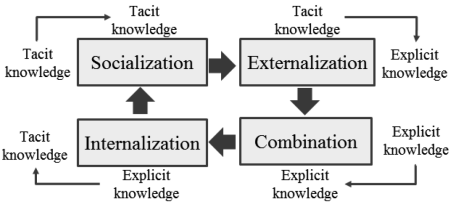
2.3 Prior Research and State of Systems

We analyzed required elements and processes in innovation in the previous subsection. On the basis of that analysis, we were able to present a model of innovation. Many systems and tools have been created to support human creativity. We surveyed the scope and coverage of innovation-related systems and tools for innovation using the innovation models presented in Fig. 2. Table 3 summarizes the results we obtained from our survey.

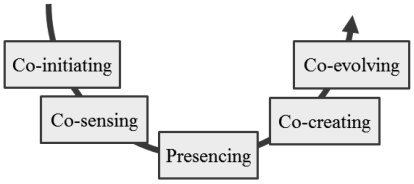
KJ-method [10] is a methodology for supporting ideation and has been used in many studies. Examples of these include a KJ-based study on systems to systems to support the idea gathering phase using radio-frequency identification (RFID) [12], and the Group KJ-method support system utilizing digital pens (GKJ) [13] groupware tool for supporting idea generation. Cheatstorm [14] researched the confluence of random information as a way of supporting new idea generation while brainstorming. Many studies have been done on system from the perspective of creating networks and a sense of place to support the introduction of social matching [15]. These systems have supported the introduction of people where creating networks has been difficult. Research has been done on the use of prototyping in the development of next-generation display interfaces [16], and this research has explained the impact of prototyping on the realization of ideas.



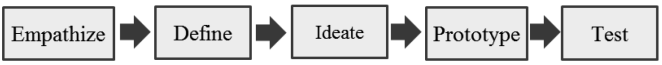
Item.1: The ten items required for discovery [2]



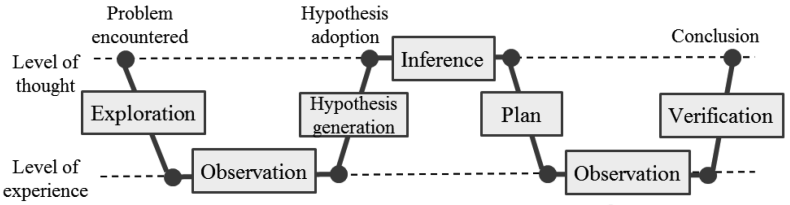
Item.6: SECI model [7]



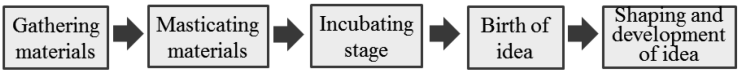
Item.7: Theory U [8]



Item.8: Introduction to design thinking process guide [9]



Item.9: W-shaped problem-solving Methodology [10]



Item.10: Technique for producing methods [11]

Fig. 1. Comparison of processes in innovation

Table 2. Analysis of processes in innovation.

Process common element	1) Sympathy	2) Creation	3) Practice	4) Succession
Cooperative elements	Network / Motivation			
Content of process common elements	·Construction of common will ·User understanding ·Sharing of tacit knowledge	·Divergent thinking ·Ideas ·Serendipity ·Convergent thinking	·Prototype ·Practice ·Action ·Evaluation	Succession of experience

2) Elements of creation	Problem institution	Information gathering	Serendipity	Judgment/decision
Detailed content	Specifics of problem essence	·Daily collection of information ·Meeting people and obtaining information	·Flashing ·Awareness ·New combinations	Decisions on solutions in problem solving

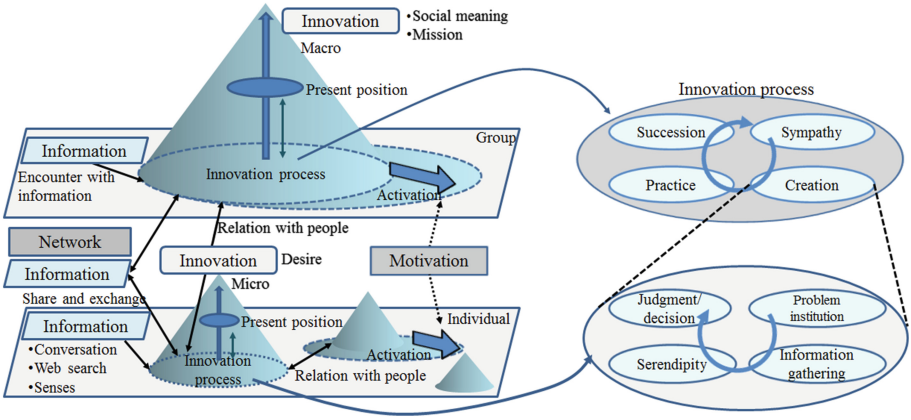


Fig. 2. Innovation model

Finally, an example of using networks is the model created by a company called Quirky [17], whose details can be found in Subsect. 2.4. Briefly, Quirky uses a system that harnesses networks to get users to propose ideas. This model has elements that improve extrinsic motivation by using remuneration.

Table 3. Analysis of existing systems.

Item	Case \ Element	Cooperative elements		Process			
		Network	Motivation	Sympathy	Creation	Practice	Succession
1	Opinion exchange convergence support system using RFID tags [12]	∠			∠		
2	GKJ: Group KJ method support system utilizing digital pens [13]	∠			∠		
3	Brainstorm, chainstorm, cheatstorm, tweetstorm: New ideation strategies for distributed HCI design [14]				∠		
4	Application and analysis of interpersonal networks for a community support system [15]	∠					
5	Paperbox- A toolkit for exploring tangible interaction on interactive surfaces [16]					∠	
6	Process of quirky [17]	∠	∠				

2.4 Model for Generation Information Using Networks

Quirky [17] is a successful example of a company with a process that leverages networks. Quirky is a New York startup that has been in business since 2009. The open processes used by Quirky have users proposing products they would like to have made. The company forms communities with users to jointly create products and market them. The specific process used by the company is outlined in Fig. 3. Individuals, who also happen to be users, submit their ideas to communities, and the values in commercializing these ideas are voted on within these communities, which therefor winnows down the proposed ideas. Quirky later decides whether to commercialize the

ideas. If the company moves forward with commercialization, it solicits opinions from the community as to product designs and naming, and then shifts to production. The greatest characteristic of this system is its influence, or the level of contribution an individual makes to products being developed. Quirky allocates money to individuals according to their influence, as well as profits from product sales. These generating ideas, voting on ideas, creating designs, and naming products are all assessed as to their level of contribution. Product manuals publicize the names of those that made contributions and where they made them. These are all ways to increase extrinsic motivation.

The Quirky model was designed to produce new innovations through the use of social networks. Moreover, there is an underlying possibility that aggressively increasing the number of worthy participants in development will lead to something unimagined.

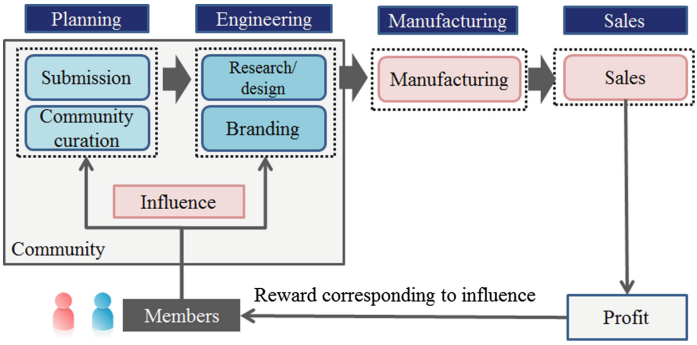


Fig. 3. Process in quirky

2.5 Issues with Existing Systems

We analyzed existing systems from the perspective of elements and processes required for innovation. The results obtained from this analysis ware the discovery that none of these systems was comprehensive and they limited their scope to only a portion of the innovation process. In particular, we could find no examples of connecting motivation with creativity.

Generating a large volume of ideas in projects requires individuals to propose good ideas. This in turn requires linking individuals to projects. The Quirky model is an example of leveraging a network to recruit ideas. Of course, that model has been successful as a means of gathering a broad range of ideas through communities. However, idea proposals have relied on individuals in Quirky, and their system does not support individual creativity. In addition, participation in projects and information gathering has also been left to individuals. This means that there have been limited encounters between people and information, which likely means little diversity. Thus, while there are examples of networks being used, information in these examples is only shared after the participants have been determined. Information gathering and exchanges must be done prior to the stage where participants have formed groups.

We can surmise from these analyses that there is insufficient support for both groups and individuals when it comes to creativity. There is also a need to support the linking of networks and motivation to produce creativity. We specifically identified three issues to be resolved.

- There is a lack of reinforcement for network activities in relation to gathering information that relies on individual actions or a meeting of people.
- The creation of ideas is entrusted to individuals, but support for individual creation is insufficient.
- Despite the fact that innovation is produced by people, there is a lack of motivational support for these people.

3 Proposed Creativity Support System

3.1 System Overview

We propose an "innovation compass" as a comprehensive system to support both individual and group creativity to solve these issues. This system supports networks and motivation, and allows individuals to fully demonstrate their capabilities. There is an outline of the system itself in Fig. 4, while system characteristics will be discussed in Subsect. 3.2.

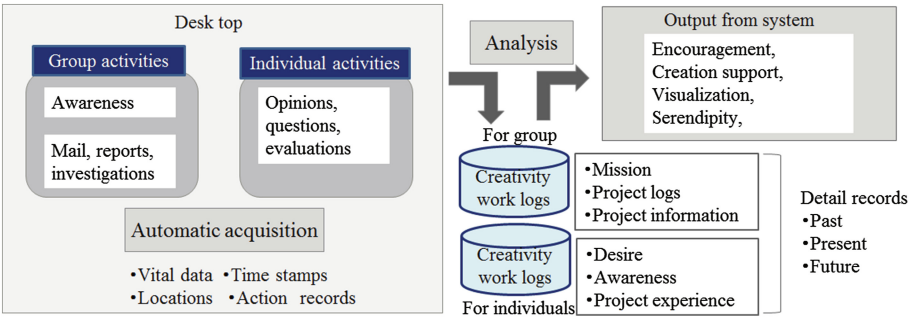


Fig. 4. Outline of creativity support system

We used a two-pronged approach to achieve such a system. First, there was separate support for both groups and mechanisms. Second, daily activity data ware gathered and analyzed for both individuals and projects in the form of creativity work logs (CWLs), as outlined in Fig. 4. The CWLs logged data for groups and individuals, and provided detailed records of the past, present, and future. Analyses of CWLs enabled systems to reach out to qualified people and projects. Moreover, CWL analysis served to strengthen interpersonal and individual-information interactions, ensured diversity, and enabled new insights. These analyses could also be used when offering support and making assessments.

3.2 System Characteristics

The Bridge Function (Bridging People, Information, and Invitations). Project registration occurs at the start of a new project. Likewise, individuals begin to participate in projects. The group CWL collects the status of project activities, and continually and automatically updates this information. For example, there are expectations not only toward voluntary participants in a project, but the system also proactively promotes the participation of qualified individuals, as can be seen in Fig. 5. For example, member A is informed of project X through the "bridge function", and by participating in the project a place is created to demonstrate A's capabilities. This satisfies the individual's sense of competency, increasing his/her intrinsic motivation. In addition, when B finds alignment between individual specialties and the issues in project X in Fig. 5, the bridge function provides answers to B from the system. The system assesses the effectiveness of the information in response to answers from B. The individual CWL of B is updated in doing so. For example, introducing personnel might be considered part of providing information, in which case B would be evaluated as a person whose specialty is making introductions using that individual's expansive network. Thus it becomes possible to reflect personal characteristics in an individual's CWL.

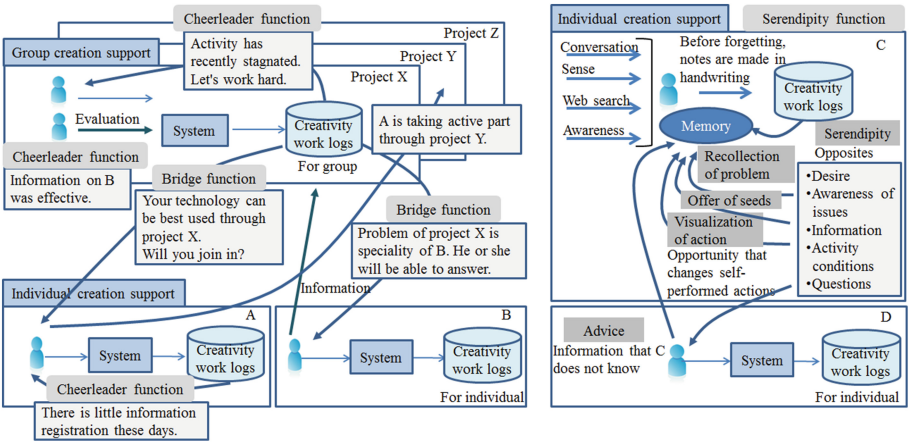


Fig. 5. Function of innovation system

Serendipity Function (Creativity Support, and Support of Insightfulness). When member C inputs information, the system presents content opposing the input information, automatically shuffles the accumulated information, and periodically provokes awareness of the issues as can be seen in Fig. 5. Individual awareness of issues becomes questionable over the passage of time, and the system can occasionally renew this awareness. In addition, the system can provide methods used to solve past issues to solve current issues. Furthermore, it provides one-stop management of all individual action records and emotion records: thus, allowing an individual to visualize their

actions. This enables you to be aware of your creation and how your design is linked to actions and emotions, which become the springboard for reforming individual action. If member C presents information on personal issues, member C can obtain advice that would not have known from member D in Fig. 5.

In addition, all types of information can be input at any time and from anywhere, as can be seen in Fig. 5. For example, team members can use mobile terminals that identify handwriting to record data on the spot while they are riding on trains or taking walks. This is done because people have short memories, and such data must be recorded before it is forgotten.

Cheerleader Function (Emotional Support and Motivation). Project progress and energy must be managed from the systems side, as outlined in Fig. 5. For example, our system monitors project progress and team energy, and when few comments are being made, the system can automatically send messages of encouragement and support to team members. Where team members suffer from a lack of ideas, they themselves can lend each other encouragement. Such encouragement can also be given in response to individual activities. When member B is assessed as having provided effective information in Fig. 5, it becomes possible to visualize the contribution B has made to the project. This allows for accurate accounting of contributions made by both individuals and groups when projects conclude, and awards can be granted based on individual activities. This ends up in improving intrinsic motivation as individuals gain a sense of significance.

3.3 Challenges in Achieving Systems

There are three challenges in creating systems that support individual and group creativity. First, there is the technological challenge of how to differentiate statements, or in other words, how to best analyze the level of contribution to a project using tagged statements, and how to match accumulated information to best use it now. The second challenge is system development. Because development involves many diverse aspects, we must take into consideration efficient methods of systems development. The third challenge is creating standards for assessment. As it is difficult to objectively assess the success of innovation, we must consider how its impact is to be measured.

4 Conclusion

We proposed a system to support creativity undertaken by both individuals and groups. We believe that we have created an opportunity for individuals to use abilities that they have not been able to use before. In addition, this system can act as a platform for innovation.

This system can be greatly varied according to work styles. It can even be thought of as a proposal for a new style of work that is not merely an extension of current continuous workflows. It is undeniable that starting something new can be difficult. Even if individuals have ideas, they often have no way of bringing these to fruition. However, companies can take on new challenges by creating environments in which

organizational barriers are eliminated and individuals' capabilities can be leveraged in group settings. People in the future will also need to conquer difficult issues, such as emerging environmental issues. To do so, it is necessary to accumulate individual knowledge and further increase problem-solving expertise as part of a group. We expect that this system will contribute to resolving numerous issues.

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