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Revising Scenario Map for Plant Management via Interaction of Stakeholders' Intentions and Constraints

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ABSTRACT

The purpose of this study is to put knowledge of plant safety together and make a map that will help to understand a system of plant and notice new links among components. This map, called the scenario map, can be used for aiding the chance discoveries - decision of various stakeholders of the system based on their awareness of latent dynamics underlying observed events. The trustworthiness of their analysis will be also reinforced by linking relevant data to the nodes and lines in the graph. In order to have stakeholders be aware of information missed in available data, we invented a method of workshop and moved forward with a rough map of plant safety. The first phase attempts to externalize differences in the bodies of knowledge of each participant. In the second, introducing Tsugo Roulette (TR) – the core component of this paper -, latent dynamics where physical and social causalities emerge is externalized. Then participants revise the scenario map based on their thoughts by the second phase, to finally evaluate the utility of nodes and lines in the graph. In accordance with each phase, participants in the workshop could exchange their tsugoes - views of intentions and constraints - and realize new links or nodes to be evaluated highly by experts in the corresponding domain.

KEYWORDSt

knowledge management, stakeholders

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1. Introduction

Chance discovery, discovering an uncertain event significant for making decisions, has been studied world widely since our definition in 2000 (see the first book in 2003 [1]). Especially if the chance event is novel, the attention to the event may trigger the creation of a new product/service that may give a new performance dimension to the human life as in Drucker's definition of innovation, and methods for realizing the new value as what Schumpeter thought originally [2]. In fact, users of methods for chance discovery went beyond their previous capability of data-based decision [3], that had been reached with tools for data mining (although some methods for predicting rare events were available since before or near 2000 [4,5]). In such successful cases, chance discovery has been positioned as the activation of humans' ability of sense-making [6], taking advantage of tools for data visualization in the process for decision making. Although areas such as evidence extraction and link discovery [7] shared this basic idea with us, our feature was to focus on effects of communications of stakeholders who share and look at a graph of relationships on events in data [1, 3, 19].

In this paper, we propose and evaluate a method of workshop for chance discovery, where participants communicate with combining pieces of knowledge and viewpoints they own. In a complex system, a field of plant management, it is difficult to make right decision because there are many factors we need to consider. Multidisciplinary stakeholders externalize *tsugoes* i.e., intentions and constraints linked to each other via latent dynamics as defined in Section 2, via communications so that latent values are mined and solutions for realizing those values are created. In Section 3 and 4, we show the core sub-process using Tsugo Roulette (TR), of which the contribution to the externalization of tsugoes and latent viewpoints are show in the following sections.

2. Tsugology: The dynamics of intentions and constrains as basis for design

A *tsugo* is a traditional Japanese word hard to be translated into other languages. In Tsugology [9], the three-tuple - intention, pre-existing constraint (pre-constraint), and post-constraint i.e., the constraint to be made due to the action – hidden behind an action is called a tsugo. A tsugo can be regarded as an essential element that should be clarified, for choosing actions that are feasible, i.e., realizes an intention under constraints that sometimes emerge from real life.

As revealed in requirement engineering, externalizing latent intentions and constraints of stakeholders are an essential step for designing acceptable products/services [10, 11, 12]. And, the tacit dimension of knowledge [13] hidden behind real activities of humans should be and can be externalized for and by enabling a creative process of collaboration in businesses [14]. A point of tsugology is that the dynamics of post-constraint, that may emerge from an action and may make a pre-constraint on others actions, in contrast to static constraints on designs in previous designing methodologies. For example, if Mr. X creates a tall building for expanding his business, the pre-constraint of habitants in the neighborhood, such as their requirement for sunshine, may be violated. In this case, the disturbance of sunshine is a post-constraint for Mr. X that had not been considered before discussing about his intention. By clarifying such a constraint, Mr.X should think of a new method, such as making a networked workplace connecting members' hometowns rather than building a new workspace, for realizing his intention to expand the residential areas of customers in his business. This intention may also get externalized via the discussion. Thus, discussing with paying attention to stakeholders' tsugoes is an essential effort for realizing products or services acceptable to various stakeholders.

Furthermore, we refined the concept sticky information [15,16,17], that is used to mean the tendency of information to be localized in the brains of individual people, who may be either an inventor in the industrial (developing, producing and selling) side or a consumer in the buying and consuming side. The information about requirements of consumers and technological knowledge of inventors are hard to be transferred from/to each other. Innovations may be disturbed if the ideas localized in the brains of users are not technically realistic or if technologies know only by inventors are not understandable to users – information stickiness is desired to be relaxed for accelerating innovations. We extended this quite essential concept sticky information into sticky tsugoes recently, i.e., tsugoes are localized in the brains of some individuals in cases innovation is not successful, vice versa [8]. That is the performance of innovations is more linked to the stickiness of tsugoes than of sheer pieces of information i.e., words in the dialogues.

3. Tsugo Roulette (TR): Tool for Externalizing Tsugoes

A Tsugo Roulette (TR hereafter: Fig.1, Fig.2) is a sheet of paper, on which one writes an action to propose, its expected results (i.e., intentions) and constraints that precede (i.e., pre-constraint) or succeed (i.e., post-constraint) the action. When participants meet, each starts describing one's own tsugoes on TR: As in Fig.1, one can start from any box among the proposed action (internal process), its effects on customers, competitors' actions, or the effects on resources (money, time, human resources etc). When one writes up to the possible extent, the sheet is passed to the next-seat colleague, so that the colleague can ask questions "why do you do this?" asking the intention, "how do you do this?" asking for the pre-constraints or for solutions, or write "no, I do not accept this because it may result in …" pointing out post-constraints by writing on a sticker. As a result, the original writer, receiving the questions/criticisms, notices important points he was missing and how the points can be grounded by words about real actions or constraints in real businesses.

TR is a mixture of tsugology, techniques for design oriented discussions, and balanced score card (BSC [20]). BSC is a prevalent tool for managing the situation of each section in a business organization that can be expressed quantitatively and qualitatively, so that the business strategies of the organization, sections, and sub-sections can be planned, linked to each other and to real situations.

In TR, the descriptions and considerations are guided by arrows showing the inter-box relate with respect to tsugoes (i.e., by showing which box means the intention, pre-constrain, or post-constraint of what are written in other boxes). For example, the upper-left box is about resource management including the plans to increase income and to reduce cost. That is the intention of managing customers for which the upper-central box is responsible. On the other hand, a suitable management strategy of customers is the pre-constraint for well doing in the financial resource management, and is also the intention of the internal process (business actions) to be filled in the central box. Thus, arrows in TR help users in choosing the boxes to fill with the answers to the questions from colleagues. Note the question of "why" and "how" correspond to the Deep Reasoning Questions (DRQ), and the Generative Design Questions (GDQ) respectively, known to contribute to designing high-quality products [21]. As well, criticisms that tend to be forbidden in brainstorming really work in improving created designs [12, 19] – these are techniques for market-oriented creative discussions.

As a result of the process with TR, participants comes to think about more concretized factors and numerical setting of goals, such as the knowledge learning for achieving one's intention or for solving the constraints. Furthermore, effects to external environment (of society or nature) will be also discussed with filling the left-bottom box. These enables to check the feasibility of created ideas, and to externalize values essential for both sides of providers (inventors) and consumers.

It is possible to redesign TR to fit application domains, because the structure of boxes and arrows in TR mean causalities. For example, let us consider applying of TR to communications for realizing safe power plants. This is about a system of systems related to various stakeholders, where multi-disciplinary discussions are desired. In designing a power plant, we put the box of internal process as "the behavior of one subsystem (component X of the plant)" and the consumer's box "the behavior of other subsystems which may be affected by X," the external process "the effects on the natural/social environment." Fig.2 shows the TR sheet for the safety management of power plants.

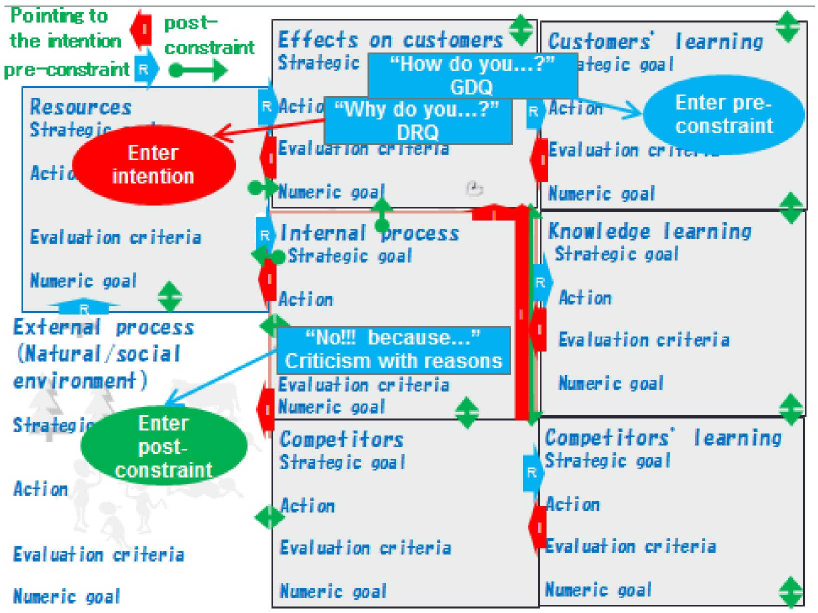

Fig. 1 A TR sheet for businesses: Questions (in the small stickers) are put in the box of the statement to ask about, returned to the original writer, who will respond externalizing the tsugoes (as in the ellipses).

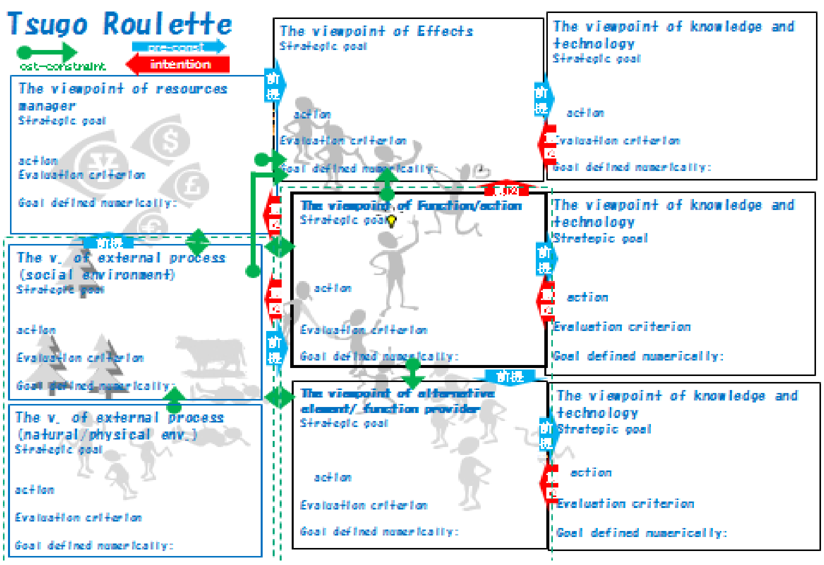

Fig. 2 A TR sheet for the safety management of power plants

4. Experiments for Evaluating the Effects of Tsugo Roulette

4.1 A case study: Application to safety of management power plant

Since 2009 we have been organizing workshops to creating ideas for enabling safe management of power plant [19,22,24], and created strategies for developing information systems for aiding the care of power plants. After the Fukushima affairs since 2011, we further realized the importance of systematic understanding and management of nuclear plants, a system embracing complex latent events and causalities that make it hard to think and discuss the scenarios in the future events in/with the system. A scenario map dealt here is a graph consisting of nodes and lines corresponding to events/actions and causalities among them, providing structural hints for systems management/design. For example, if a plant inspector finds a crack at a particular pipe, visualizing multiple possibilities of scenarios of that part in the future which may result from different actions, by showing a node-to-node connections via lines corresponding to event (/action)-to-event causal relations, will enable a reasonable decision. Furthermore, the thoughts will be the more objective and trustworthy if nodes and lines in a scenario map are the finely linked to evidential data in technical papers and reports. The scenario map differs from event trees used for PSA [23] – the scenario map focuses more to human's cognitive process to decision making.

Here we propose a workshop using TR for creating a scenario map including events relevant to physical and social reactions to behaviors of power plants, following the procedure shown below. We had participants from the energy industry, the government, researchers of nuclear engineering, etc, who are stakeholders of power plant technology. This is a method of workshop with viewing and revising a scenario map, with noticing differences among their own viewpoints particularly when they come from different organizations, and latent dynamics underlying events discussed at each time. A scenario map developed via this process reflects the viewpoints and tacit dimensions of knowledge of various stakeholders - on-site workers, plant designers/managers, etc. The workshop consists of the four phases below:

Phase1) Externalize differences of viewpoints and knowledge: Participants share a large (A0) printed scenario map (Fig.3-L) to fill out missing lines and nodes, explaining each other the reasons why they added them on the map. We assigned participants different-colored pen in order to tell who added/marked/rejected each node/line.

Phase2) Externalize intentions, pre- and post-constraints behind each participant's action: Integrating the balanced score card (BSC) and requirement acquisition in design methodology [10-12], we introduced TR for filling with actions/events that can be the required conditions or the results of proposed actions. Participants could think about one's own and others' tsugoes ([8,9] intentions and pre-/post-constraints), by filling boxes on the sheet. Participants exchange the sheet with neighbors, so that they can afterward get feedbacks that may point out the missed attention to essential elements/dynamics of the plant, and reflect the feedback to revisions of the form.

Phase3) Position pieces of their knowledge on the map: Participants put stickers on nodes in the shared scenario map, related to their descriptions on the TR, and draw additional nodes/lines in the map.

Phase 4) Evaluate parts of the scenario map: Participants evaluate nodes and lines considering their evaluation of the importance, the feasibility, and the consistency, that may enable to promote discussions and further revisions of the map. Based on these evaluations, they reconstruct the map after the workshop. Nodes and lines may be added, also stickers get labeled with conceptual words.

The scenario map prepared here was in the upper of Fig.4, where events are linked from/to each other according to causal relations, on which inspectors and safety managers can consider possible future scenarios. Because causalities tend to be missed in the original scenario map, we applied TR in the workshop where 6 experts (from power industry and the government) came to meet and discuss. First they looked at the original map and discussed its correspondence with real causalities. Then, they executed the process with TR - filled and exchanged TR sheets with asking questions using post-its - and finally added nodes and links if necessary. The obtained scenario map is shows in the lower of Fig.4 (using Graphviz: www.graphviz.org). The colored nodes were added in this process, and the ones with bold ellipses represent ones that came out to be finally evaluated as "noteworthy events for managing the safety of power plant" by experts of plant engineering who did not attend the workshop.

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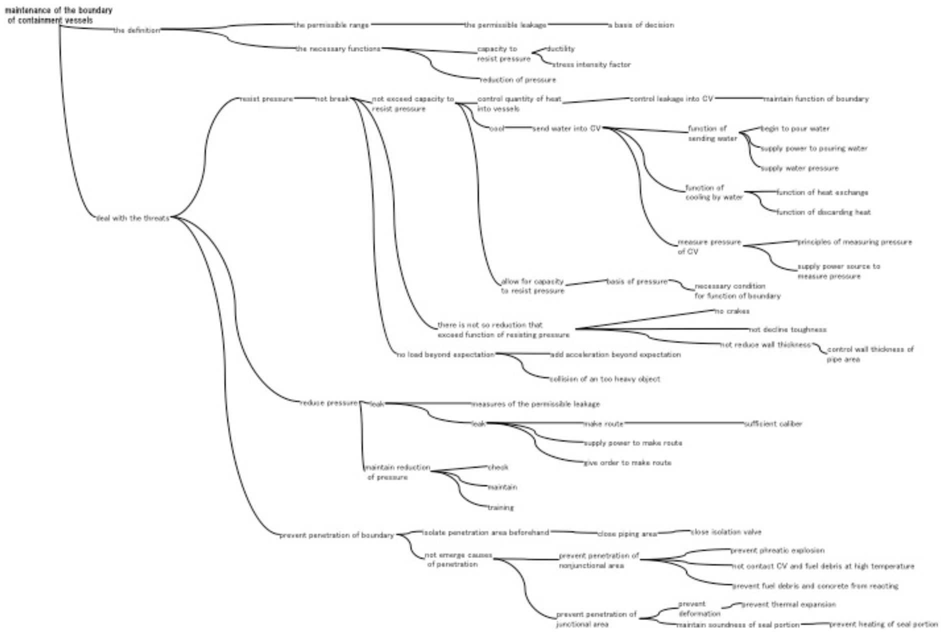
Fig.3 Scenes of the workshop (left: revising the scenario map in Phase 1 and 3, right: filling and revising TR sheets in Phase 2)

As a result, 18 nodes (i.e., events) among 30 evaluated as noteworthy by one or more turned out to have been added in the TR-based process. Furthermore, 6 among 8 evaluated as noteworthy by two or more were from the process. Considering we had 46 nodes added to the original map including 64 nodes, i.e., 42% in the generated were added ones, the 60% (18/30) and 75% (6/8) in these results mean the highly evaluated nodes were more likely to be added by using TR, than by experts drawing the map free hand. This conclusion may be controversial - the discussion before using TR sheets may have caused the success. However, according to interviews after the WS, all the participants commented the TR worked in externalizing the essential viewpoints and problems. Thus, the proposed method would be useful for developing a scenario map to be employed to aid stakeholders' consideration of essential constraints and intentions.

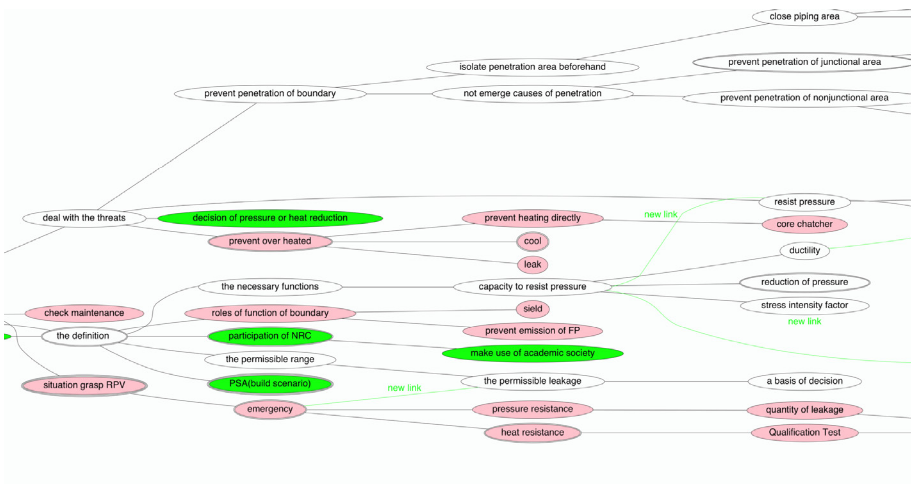
4.2 Tendencies in 38 TR sheets

In addition to the 6 TR sheets, we had experiments of TR-based workshops about technologies for safe cities (16 students) and promising businesses in service industry (16 business people). All participants were new to TR. In total we had 38 TR sheets. By thus mixing cases, we aim at finding general tendencies that stand regardless of domains.

As in Fig.5, for the obtained TR sheets after the workshops, the letters were written and corrected/added, after each question was put on stickers. Transcribing all entries in boxes into text data, and tracing the questions and corresponding answers (if any), we obtained the analysis results as follows. Here, Table 1 shows the number of sentences entered before (upper four rows) and after (lower four rows) the question-asking via stickers: In all cases we restricted each TR-exchanging group into a pair, i.e., two participants asked questions to each other, so we can divide the workshop time into before and after questions. The bold letters show comparably large values, that are larger than 0.75 (0.24) for before (after) questions: We set these different thresholds because the number of sentences after the questions as larger than before, in all TR sheets.



(a) The original (prepared) scenario map



(b) A part of the generated (using TR) scenario map

Fig.4 Scenario maps (a) before and (b) after the TR-based procedure: nodes represent events, connected by causal links provided by experts of power plant engineering: This figure is just for showing the structural overview – small letters can be ignored.

(1) The goal settings (both strategic and numeric, and the criteria for evaluating the performance of tasks) tend to be entered before questions, just by writing on one's own thoughts.

(2) The actions, that are the concrete solutions for achieving the goals, tend to be entered for asking questions. In other words, GDQ-type questions "how do you achieve these goals?" are found to work on TR (from Table 1). And, DRQ-type, i.e., "why?" also works here, e.g,, "why do you only check the plant situation?" on which the original writer noticed his own intention was to assess risks of accidents, and added "I should also define the numerical criteria and continue the monitoring." Missed sub-goals were found due to this effect, as participants' common comments that TR worked in externalizing essential viewpoints and problems (from the case study).

An additional evidence supporting (2) was that sentences entered before questions in the case of power-plant management was mostly of physical behaviors, whereas the focus (frequent words on the

TR sheet) shifted to humans' actions such as politics, review, planning, safety assessment. Words such as CV (containment vessel), pressure, accident, were common to both before and after the questions: The causality between accidents and pressures on the CV was really the most frequent topic in the questions on stickers.

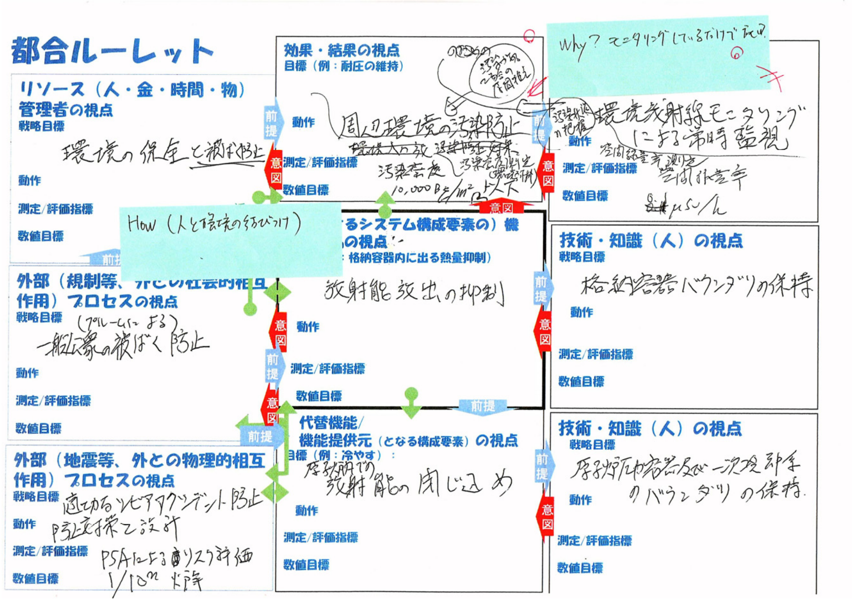


Fig.5 A TR sheet (filled in Japanese) in the case of the proposed workshop: We find questions on stickers, and entries answering them. We counted the sentences in each box, and those that are obviously responding to the questions according to the words used and arrows written (ambiguous entries were ignored).

Table 1. The proportion (number) of sentences in each box, entered before and after asking questions, i.e., the values before plus after is 1.0 in each box.

		Resource	Effect (customers)		Internal process		Alternative (competitors)		External process	
Before	Strategic goal	0.75 (24)	0.74 (35)	**0.79 (30)**	**0.84 (36)**	**0.91 (29)**	**0.81 (26)**	**0.95 (18)**	**0.76 (19)**	0.71 (5)
	Planned action	0.70 (19)	0.69 (25)	**0.77 (24)**	0.71 (29)	0.74 (23)	0.68 (19)	0.71 (10)	0.68 (15)	**1.00 (3)**
	Evaluation criteria	**0.88 (15)**	**0.81 (17)**	**0.92 (12)**	**0.76 (13)**	0.75 (12)	**0.79 (11)**	**0.83 (5)**	0.62 (8)	**1.00 (1)**
	Nemeric goal setting	**0.90 (9)**	**0.92 (12)**	0.64 (7)	**0.83 (10)**	**1.00 (9)**	**1.00 (4)**	0.75 (3)	**1.00 (4)**	**1.00 (1)**
After	Strategic goal	**0.25 (8)**	**0.26 (12)**	0.21 (8)	0.16 (7)	0.09 (3)	0.19 (6)	0.05 (1)	0.24 (6)	**0.29 (2)**
	Planned action	**0.30 (8)**	**0.31 (11)**	0.23 (7)	**0.29 (12)**	**0.26 (8)**	**0.32 (9)**	**0.29 (4)**	**0.32 (7)**	0.00 (0)
	Evaluation criteria	0.12 (2)	0.19 (4)	0.08 (1)	0.24 (4)	**0.25 (4)**	0.21 (3)	0.17 (1)	**0.38 (5)**	0.00 (0)
	Nemeric goal setting	0.10 (1)	0.08 (1)	**0.36 (4)**	0.17 (2)	0.00 (0)	0.00 (0)	**0.25 (1)**	0.00 (0)	0.00 (0)

5. Conclusions

Although rare events may be predicted in existing technologies on data mining, we still require human's thoughts and communications for decisions taking advantage of an event. Studies on chance discovery have been, based on this philosophy, developing tools of data visualization and methods of workshop. We can say chance discovery can be a trigger to innovation, and this trigger can be reinforced by using such methods as our workshop.

We here showed a workshop for having multiple stakeholders of a certain business domain meet, playing real or imaginary roles in the market, via visualizing or discussing the relationships among existing pieces of knowledge and technologies. In this paper we focused on tsugoes, that are the core of information that should be externalized and communicated. We showed effects of tsugoes' externalization to the creation of innovative ideas and to the awareness of essential viewpoints for problem solving, from experiments. In the future work, we aim at expanding application domains to designing systems of systems, with developing meta-processes that are the combinations of TR and other processes for chance discovery.

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