What is it to structuralize with multiple viewpoints by using Goal Structuring Notation (GSN)?

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Abstract

Having multiple viewpoints are an indispensable capability for persons who can lead the development and operation of large-scale complex technological and social systems. In addition, the previous study describes as follows. “Citizens are diverse because our society has become more complex in recent years. Therefore how to evaluate, how to satisfy the required level of accountability, and how to reach a good agreement are problems that must be addressed.”

This study therefore aims to evaluate whether Goal Structuring Notation (GSN) is a notation method structuralizing with multiple viewpoints for agreement formation. Through the evaluation, this study intends to clarify what it is to structuralize with multiple viewpoints by using GSN. A quantitative evaluation method and a qualitative evaluation method are used for data analysis. This study discusses structuralizing with multiple viewpoints.

Concretely, this study showed that structuralizing with multiple viewpoints: 1) Connects multiple viewpoints, creates new boundaries, and enables structuralizing what was described by using GSN, when multiple Strategy nodes are used. 2) Enables expressing a combination of a viewpoint that is selected from multiple viewpoints aligned in the horizontal direction, and a viewpoint that is selected from multiple viewpoints aligned in the vertical direction, when one Strategy node is used. 3) Enables discovering an unexpected viewpoint through a conversation using GSN.

Finally, this study concludes with future research topics.

Keywords: Multiple Viewpoints, Structuralizing, Goal Structuring Notation, D-Case, Assurance Case

1. Introduction

Having multiple viewpoints are an indispensable capability for persons who can lead the development and operation of large-scale complex technological and social systems. [1] In addition, Horie et al. [2] describe following. “Citizens are diverse because our society has become more complex in recent years. Therefore how to evaluate, how to satisfy the required level of accountability, and how to reach a good agreement are problems that must be addressed.”

This study therefore aims to evaluate whether Goal Structuring Notation (GSN) [3] is a notation method structuralizing with multiple viewpoints for agreement formation described by Horie et al [2]. GSN is useful in the fields including management. [4] Through the evaluation, this study intends to clarify what it is to structuralize with multiple viewpoints by using GSN. A quantitative evaluation method and a qualitative evaluation method are used for data analysis. We then discuss structuralizing with multiple viewpoints.

In the following part, the novelty of this study is described. GSN is a notation method that supports implicitly structuralizing with multiple viewpoints. There are seemingly no studies that evaluate GSN in terms of structuralizing with multiple viewpoints. Horie et al. discuss the framework of evaluation in terms of multi-frames, multi-criteria, and multi-subjects, particularly with regard to environmental issues. [2] GSN for structuralizing with multiple viewpoints however is not discussed, which differs from this study.

Shirasaka et al. [1] describes as follows. “One of the main objectives of the class design is to have students gain multiple viewpoints. However, the design does not directly evaluate whether the students have it or not.” Shirasaka et al. [1] discuss conducting classes with an aim to develop human resources with multiple viewpoints. There is a difference from this study in that a notation method is not discussed.

Thus the novelty of this study lies in evaluating whether GSN enables structuralizing with multiple viewpoints.

Section 2 summarizes GSN description method. Section 3 describes quantitative evaluation methods and qualitative evaluation methods. Section 4 shows and discusses evaluation results using the evaluation methods presented in Section 3. Section 5 concludes with future research topics.

2. Goal Structuring Notation

GSN [5], which was proposed by Kelly, is one of the notation methods used for assurance cases. [6] Assurance cases extend the discussion area to the whole quality of the discussed system. D-Case (Dependability-Case) is an description method using six nodes, including Goal node, Context node, Strategy node, Evidence node, Monitoring
node, and Undeveloped node. [7] [8] [9] Table 1 shows the six nodes. Strategy node, which is used in this study are relevant both to D-Case and GSN, and is related to structuralizing with multiple viewpoints. The reason is Strategy node shows the viewpoint for decomposing the subject to be discussed. The nodes used in this study are shown with double quotation marks (“ ”).

Table 1: Explanation of Six nodes for D-Case

| Node      | Figure | Explanation                                                                 |
|-----------|--------|-----------------------------------------------------------------------------|
| Goal      |        | Goal node describes what to assure, with a combination of a subject and predicate. |
| Strategy  |        | Strategy node describes how to break down the Goal into sub-goals leading to the lower layer. |
| Context   |        | Context node describes the state, or environment and conditions of the System, and shows ways to lead to the Goal and Strategy. |
| Evidence  |        | Evidence node eventually assures that we can reach the Goal, and shows ways to lead to the Goal. |
| Monitoring|        | Monitoring node is intended to represent Evidence available at runtime, corresponding to the target values of in-operation ranges. |
| Undeveloped|       | Undeveloped node shows the status that there is no Evidence or Monitoring, or discussion supporting the Goal. |

3. Evaluation Methods

The evaluation method is shown in Figure 1.

As shown in Figure 1, after conducting a face-to-face lecture and a questionnaire survey in Japan on 17th June 2017, we analyzed the questionnaire results.

First, we describe the lecture. The subjects were beginners who did not know much about GSN. The reason was that those who regularly uses GSN were not likely to have negative comments on GSN.

For the evaluation method, we had the subjects describe GSN without explaining, when giving assignments, that GSN is a method for structuralizing with multiple viewpoints. The reason being that we considered the explanation in advance would affect the results. Subsequently, the subjects had a conversation with each other by using GSN they described.

For describing GSN, we gave the participants the theme of "How do you assure the realization of improved customer satisfaction, assuming you are running a company of Japanese 100-yen shop business?". We chose this theme, which was easy for participants to work, and could come up with various answers.

Next, we will describe the questionnaire. Responses were given on a seven-point ordinal scale, ranging from -3-"disagree," to +3-"agree," with 0 representing "neither agree nor disagree." Scores from +1 to +3 were assumed to be valid for "Criteria of assessment" in Table 2.

In line with the purpose of this study, we intended to evaluate that GSN can structuralize with multiple viewpoints, and thus decomposed "structuralizing with multiple viewpoints" into "being able to select all the viewpoints" and "being able to structuralize with a combination of multiple viewpoints".

In relation to the purpose of this study, GSN needs to be able to be described, which is judged at the time GSN is used.

We made questionnaire statement as shown in Table 2 in order to make the above-mentioned evaluation.

Table 2: Correspondence of "Criteria of assessment" and "Questionnaire statement".

| Criteria of assessment               | Questionnaire statement                                           |
|--------------------------------------|-------------------------------------------------------------------|
| Structuralizing with multiple viewpoints | GSN can structuralize with multiple viewpoints.                   |
| Being able to select all the viewpoints | Strategy node can describe all the decomposed viewpoints.          |
| Structuralizing with a combination of multiple viewpoints | The method of structuralizing with multiple viewpoints was understood. |
|                                       | A combination of multiple viewpoints enables structuralizing with multiple viewpoints. |

With regard to the questionnaire, we considered in this study that Strategy node needs to be able to describe all

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the decomposed viewpoints in order to evaluate multiple viewpoints. Additionally, we considered that the method of structuralizing needs to be understood. With the method being realized by the combination of “Strategy node” and another “Strategy node”, we confirmed that a combination of multiple viewpoints enables structuralizing with multiple viewpoints.

Overall, we confirmed whether GSN enables structuralizing with multiple viewpoints. The subjects are likely to answer “Agree” only when they agree with the statement. The reason is they were not informed in advance that this was an evaluation on structuralizing with multiple viewpoints, and they worked on the assignment given without knowing what is required for the questionnaire answers.

With regard to the qualitative data analysis, we used free descriptive answers as data, and had three experts of both qualitative research methods and GSN analyze the data by using qualitative coding methods. The procedure was as follows: [10]

Step 1: View the free answers, and pick those are related to structuralizing with multiple viewpoints. Set the viewpoint for Affinity Diagram grouping (Step 2). It was set in this study as “What the GSN user can get by using GSN,” in order to show for structuralizing with multiple viewpoints.

Step 2: Look for, from the aforementioned viewpoint, the descriptions related to structuralizing with multiple viewpoints, and sort them into groups.

Step 3: Write titles for each group that summarizes the essence of the group, at a slightly higher level of abstraction (called “Open coding results” in this study).

The reason we used qualitative qualitative coding methods was to clarify "what it is to structuralize with multiple viewpoints by using GSN".

4. Results and Discussion

4.1 Results

The subjects of this study are as shown in Table 3. Results of questionnaire statement are shown in Table 4. Table 5 - Table 8 show the open coding results of the free descriptive answers.

Table 3: Cross-tabulation table of "Age" and "Sex"

| Age | Male | Female | Total |
|-----|------|--------|-------|
| 20's| 5    | 4      | 9     |
| 30's| 4    | 5      | 9     |
| 40's| 4    | 0      | 4     |
| 50's| 1    | 2      | 3     |
| Total| 19  | 11     | 30    |

This study ensured the validity of analysis through the subjects’ review on the open coding results. [11] The reason we chose beginners, who do not much about GSN, as the analyzers was that beginners were likely to eliminate GSN experts’ bias for reviewing open coding results.

4.2 Discussion

This section discusses first the quantitative evaluation results (Table 4). The average value exceeded zero, suggesting the values were effective for each questionnaire statement.
Collectively Exhaustive (MECE)

think to divide a target into Mutually Exclusive and

from GSN helps the GSN creators find unexpected viewpoints

describe the structure by combining the viewpoints.

viewpoints from the horizontal direction and the

open coding results for which GSN can structuralize with

evaluation results (Table 5

ability of the creators.

viewpoints from the layered-direction.

likely to be referring to the layered-relationship of

viewpoints, and thus structuralizing viewpoints from the vertical direction.

“Depend on the GSN creator’s capability”: This result suggests GSN users are likely to be able to express the viewpoints from the horizontal direction and the viewpoints from the vertical direction, and thus the viewpoints are unlikely to be expressed depending on the ability of the creators.

Table 6: Open coding results for the Questionnaire statement “Strategy node can express all the decomposed viewpoints”.

| Open coding results                                      | Number of sentences |
|----------------------------------------------------------|---------------------|
| Being able to think of viewpoints.                       | 4                   |
| Being able to simply summarize viewpoints.               | 2                   |
| The structure of the viewpoint gets complicated.         | 2                   |
| It can easily be decomposed by describing it step by step.| 1                   |
| At the time of describing GSN, GSN creator cannot notice that there is a leakage. | 1                   |
| GSN users can freely set the viewpoint.                  | 1                   |
| Needing a mechanism to support how to cut viewpoints.    | 1                   |
| GSN users can communicate without misunderstanding when sharing viewpoints with others. | 1                   |

Table 7: Open coding results for the Questionnaire statement “The method of structuralizing with multiple viewpoints was understood”.

| Open coding results                                      | Number of sentences |
|----------------------------------------------------------|---------------------|
| Setting Strategy node.                                    | 11                  |
| Describing using GSN                                      | 6                   |
| Combining strategies and strategies.                      | 3                   |
| Securing the number of viewpoints through conversation with others. | 2                   |
| Describing using GSN is not an assurance.                 | 1                   |
| Have a feeling that the object is described in more details by using GSN. | 1                   |

With regard to the open coding results of qualitative evaluation results (Table 5 – Table 8), it first discusses open coding results for which GSN can structuralize with multiple viewpoints.

“Being able to describe the structure among viewpoints”: This result suggests the subjects are likely to recognize structure the gap among viewpoints, and describe the structure by combining the viewpoints.

“Being able to view from various angles by thinking a think to divide a target into Mutually Exclusive and Collectively Exhaustive (MECE)”: This result suggests GSN helps the GSN creators find unexpected viewpoints from the horizontal direction.

“Being able view from multiple viewpoints owing to a layered-structure”: This result suggests GSN users are likely to be referring to the layered-relationship of viewpoints, and thus structuralizing viewpoints from the vertical direction.

“Depend on the GSN creator’s capability”: This result suggests GSN users are likely to be able to express the viewpoints from the horizontal direction and the viewpoints from the vertical direction, and thus the viewpoints are unlikely to be expressed depending on the ability of the creators.

“Being able to view from multiple viewpoints owing to a layered-structure”: This result suggests GSN users are likely to be referring to the layered-relationship of viewpoints, and thus structuralizing viewpoints from the vertical direction.

Table 8: Open coding results for the Questionnaire statement “A combination of multiple viewpoints enables structuralizing with multiple viewpoints”.

| Open coding results                                      | Number of sentences |
|----------------------------------------------------------|---------------------|
| Being able to express viewpoints                          | 7                   |
| Feeling to structuralize with conscious of different viewpoints. | 6                   |
| Being able to express GSN users’ thinking.               | 4                   |
| After creating GSN, it can be to check structuralizing.   | 3                   |
| One tried using GSN.                                     | 2                   |
| Feeling that hierarchies to express are various.          | 2                   |
| Beginning to look widespread                             | 2                   |
| The relationship between the high-level viewpoint and the low-level viewpoint has a structure that details the high-level viewpoint. | 2                   |

Depending on the competence of the GSN creators. 1

“Being able to structuralize with multiple viewpoints by confirming with others”: By having a conversation with GSN, it is possible to confirm the viewpoint of what GSN creator is thinking. As a result, GSN users will be able to discover the viewpoint they did not come up with. It therefore suggests that different viewpoints can be recognized.

“Being able to structuralize with multiple viewpoints in your thinking”: This result suggests that structuralizing is likely in the range the GSN creators can think.

“Many viewpoints are noticed after subjects viewing the results of other subjects, or getting comments from other subjects on their own results”: It is thought that GSN users can discover the viewpoint they did not come up with the conversation.

“Being able to think from multiple viewpoints”: By using this way of thinking, it is thought that it can think with multiple viewpoints. Therefore, by continuous use of GSN, it suggests that it becomes training for structuralizing with multiple viewpoints.

“The more you refine it, the wider your view”: By being in details, the range expressed in each goal node becomes narrower. However, by increasing the number of viewpoints, it is considered that the viewpoint in the vertical direction is expanded.

“It can easily be decomposed by describing it step by step”: This result shows that the multiple viewpoints are selected and structuralized in order.

“GSN users can find the creator’s thought pattern”: Since GSN users can think of the creator's thought pattern, it shows that GSN users can understand the order GSN creator's viewpoint is structuralized. Thus, GSN expressed a viewpoint from the horizontal direction and viewpoint from the vertical direction. Moreover, a conversation with GSN enabled discovering
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an unexpected viewpoint. We therefore conclude that GSN is effective for structuralizing with multiple viewpoints.

Subsequently, we discuss the open coding results of the questionnaire statement “Strategy node can describe all the decomposed viewpoints”.

“Being able to think of viewpoints”: This result shows that you are selecting by being able to think of viewpoints.

“Being able to simply summarize viewpoints”: This result shows that GSN users were able to summarize the viewpoint.

“The structure of the viewpoint gets complicated”: This result recognizes complexity by recognizing the structure of the viewpoint.

“It can easily be decomposed by describing it step by step”: This result shows that it is easy to select multiple viewpoints by creating viewpoints in order.

“At the time of describing GSN, GSN creator cannot notice that there is a leakage”: Since it cannot be automatically checked that there is a leakage, it shows that they cannot notice whether one's selected viewpoint is correct.

“GSN users can freely set the viewpoint”: This result shows that the viewpoint can be freely selected.

“Needing a mechanism to support how to cut viewpoints”: This result shows that need a mechanism to support to divide the viewpoint after selecting the viewpoint.

“GSN users can communicate without misunderstanding when sharing viewpoints with others”: This result shows that GSN is effective for sharing viewpoints with third parties. Thus, we confirmed that subjects recognize and select multiple viewpoints by using GSN. We therefore conclude that GSN is effective for expressing all the decomposed viewpoints.

Subsequently, we discuss the open coding results for the questionnaire statement “The method of structuralizing with multiple viewpoints was understood”.

“Setting Strategy node”: By using “Strategy node”, it is possible to represent the viewpoint and therefore it is a method structuralizing with multiple viewpoints.

“Describing using GSN”: By using GSN, it is considered to be a method structuralizing with multiple viewpoints.

“Combining strategies and strategies”: Combining “Strategy node” and another “Strategy node” is a combination of viewpoint and viewpoint, and it is considered to be a method structuralizing with multiple viewpoints.

“Securing the number of viewpoints through conversation with others”: Multiple viewpoints are born by the conversation using GSN, which is considered to be a method structuralizing with multiple viewpoints.

“Describing using GSN is not an assurance”: It is pointed out that writing GSN is not an assurance.

“Have a feeling that the object is described in more details by using GSN”: By using GSN, it states that there is a feeling that the subject of discussion is described in more details. This is considered to be a method structuralizing with multiple viewpoints.

Thus, using GSN (especially the combination of “Strategy node” and another “Strategy node”) connects multiple viewpoints and enables structuralizing. We therefore consider it as "a method of structuralizing with multiple Viewpoints".

Subsequently, we discuss open coding results for the questionnaire statement “A combination of multiple viewpoints enables structuralizing with multiple viewpoints”.

“Being able to be hierarchized”: GSN users can be hierarchized by using a combination of “Strategy node” and another “Strategy node”, they consider it as structuralizing with multiple viewpoints.

“Being able to express that the viewpoint is divided”: By using a combination of “Strategy node” and another “Strategy node”, it can express those plural viewpoints are divided, so it can be considered structuralized with multiple viewpoints.

“Feeling to structuralize with conscious of different viewpoints”: By using a combination of “Strategy node” and another “Strategy node”, it is considered that he can structuralize with multiple viewpoints since they experienced structuralizing with conscious of multiple viewpoints.

“Being able to express GSN users’ thinking”: By using a combination of “Strategy node” and another “Strategy node”, GSN users can describe one’s way of thinking, they consider it as structuralizing with multiple viewpoints.

“After creating GSN, it can be to check structuralizing”: By using a combination of “Strategy node” and another “Strategy node”, GSN users recognized that it can be used for checking whether structuralizing can be done after GSN creating, therefore it can be structuralized with multiple viewpoints.

“One tried using GSN”: Since GSN users tried using GSN, it can be considered that it can be structuralized with multiple viewpoints. If you feel that structuralizing is not possible with multiple viewpoints, we do not consider that this impression will come out.

“Feeling that hierarchies to express are various”: Since it can be recognized that there are various hierarchies to express by using a combination of “Strategy node” and another “Strategy node”, it can be considered that it can be structuralized with multiple viewpoints. If not, it can be considered that GSN users cannot feel that there are various hierarchies to express.

“Beginning to look widespread”: By using a combination of “Strategy node” and another “Strategy node”, it is now possible to see an object over a wide range, GSN users consider that it can be structuralized with multiple viewpoints. If not, it can be considered that the object cannot be felt that the object will become widely visible.

“The relationship between the high-level viewpoint and the low-level viewpoint has a structure that details the high-level viewpoint”: By using a combination of “Strategy node” and another “Strategy node”, it describes the structure of the high-level viewpoint and the low-level viewpoint.

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viewpoint, and it is considered that it is structuralized with multiple viewpoints.

“Depending on the competence of the GSN creators”: Since having structuralizing with multiple viewpoints is dependent on the competence of GSN creators, it is considered that having the competence is another problem.

Thus, the subjects are likely to recognize multiple viewpoints and structuralizing through the combination of “Strategy node” and another “Strategy node”. We therefore consider that GSN enables structuralizing with multiple viewpoints.

5. Conclusions

This study aimed to evaluate whether GSN is a notation method structuralizing with multiple viewpoints for agreement formation. The evaluation results showed the effectiveness of GSN for structuralizing with multiple viewpoints.

Moreover, this study aimed to clarify what it is to structuralize with multiple viewpoints by using GSN, and showed that structuralizing with multiple viewpoints:

- Connects multiple viewpoints (“Strategy node”), creates new boundaries and enables structuralizing what was described by using GSN, when multiple Strategy nodes are used.
- Enables expressing a combination of a viewpoint that is selected from multiple viewpoints aligned in the horizontal direction, and a viewpoint that is selected from multiple viewpoints aligned in the vertical direction, when one Strategy node is used.
- Enables discovering an unexpected viewpoint through a conversation using GSN.

"A viewpoint that is selected from multiple viewpoints aligned in the horizontal direction" is a viewpoint chosen for decomposition. It shows that GSN users can consider how to divide when dividing by the viewpoint.

"A viewpoint that is selected from multiple viewpoints aligned in the vertical direction" refers to a viewpoint generated through a combination of multiple layers. Structuralizing with multiple viewpoints by using GSN refers to connecting multiple viewpoints in layers.

Effects for connecting multiple viewpoints in layers are described as "ensuring the traceability of the highly abstract concepts and lower abstract concepts by using assurance cases is effective in improving the feasibility of accomplishing highly abstract concepts."[7]

GSN can be to support discovering the viewpoints that we could not think of through conversation. From the above, GSN is considered to be effective as a method to foster multiple viewpoints in the human resources described by Shirasaka et al. [1].

Future research topics include solving the following problems of GSN, which needs to be addressed for the proposed method to be used in education:

- Develop description rules and guidelines for creating assurance cases to address the eight challenges. [4]

- Creating assurance cases is straightforward enough to understand without a lecture in person, but not necessarily easy. [4]

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