International Journal of Computer Information Systems and Industrial Management Applications.
ISSN 2150-7988 Volume 8 (2016) pp. 023–032

Visualizing Self- and Peer-assessment Data by a Self-organizing Map for Inducing Awareness in Learners

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Abstract: **Self- and peer-assessments among learners are presumed to motivate learners to increase their learning and introspection. The basis behind this effect is the awareness resulting from differences between a self-assessment result and the assessment results from others. Therefore, to enable learners to benefit from self- and peer-assessments, we need to easily visualize results that make them aware of some factor that could improve their learning ability. In this study, we designed a system to visualize self- and peer-assessment data, which are many and multi-dimensional data, in such a way that we can easily grasp an overview at first glance. We then developed an actual system using a self-organizing map (SOM) as a method for visualizing self- and peer-assessment data. In a comparison of the visualization method in our developed system, SOM, and a conventional method, a radar chart, we showed the usefulness of our visualization method, SOM, through a subjective evaluation test and a statistical hypothesis test. In addition, we carried out an experiment in which people wrote reports, then conducted self- and peer-assessments of what they wrote by using the developed system. The experimental results showed that the visualization of self- and peer-assessment data enabled people to become aware of some factor that helped them to improve their reports.**

Keywords: self-assessment, peer assessment, self-organizing map, visualization, awareness

I. Introduction

In the educational research field, studies on self-assessment [1] and peer-assessment [2] among learners in higher education have been attracting interest. Some studies investigate only self-assessment [3] or only peer-assessment [4][5], and some investigate both types [6][7][8][9][10]. Although the roles of self- and peer-assessments in higher education are different, they are considered to motivate learners to enhance learning and introspection. One of the reasons for the increased attention to self- and peer-assessments is the change in the learning perspective. That is, the traditional notion that teachers disseminate knowledge to learners is changing to the notion that learners construct knowledge through their social interactions. Self- and peer-assessment behaviors are just social interactions utilized in the process of constructing knowledge.

In higher education, the simultaneous application of self-assessment and peer-assessment enhances learning and introspection of learners, as mentioned above. The basis behind this effect is awareness of the differences between self- and peer-assessment results. Therefore, to verify the learning effects, it is necessary to show the results of self- and peer-assessments in a comprehensible way to the learners.

In this study, we designed a system for visualizing many and multi-dimensional data of self- and peer-assessments in a way that learners can intuitively grasp the outline of the data. In addition, as an example of the designed system, we developed an actual system for visualizing self- and peer-assessment data on the "Fundamental Competencies for Working Persons" defined by the Ministry of Economy, Trade and Industry in Japan [11]. These competencies are the basic abilities required for various people to work together in the workplace and in local communities. Furthermore, we evaluated a method to visualize self- and peer-assessment data by conducting subjective evaluation tests for comparison with the conventional visualization method, which is a radar chart. In addition, we carried out an experiment in which people wrote reports, then conducted self- and peer-assessments of what they wrote by using the developed system.

In the system developed in this study, we first map many and multi-dimensional self- and peer-assessment data to a two-dimensional space by a self-organizing map (SOM) [12] and draw the mapped data for visualization. SOM is a method for nonlinear data mapping from a high-dimensional space to a lower-dimensional space that maintains the relative positions of the data as precisely as possible. Therefore, SOM can be used for visualization. The visualized map here is a set of units arranged in the two-dimensional space. A numerical vector with the same dimension as the original data is assigned to each unit. SOM updates the assigned vectors to the units, and each of the original data is finally mapped on a unit with its most similar vector.

The remainder of the paper is organized as follows. Section II describes related work. Section III shows our designed system for inducing the awareness of learners. Section IV shows the system developed according to the design described in Section III. Section V shows the results of a subjective evaluation test for validating the visualization method of the developed system. Section VI shows the system for conducting self- and peer-assessments of reports that people write and Section VII shows the experimental results to use the system for self- and -peer-assessments of reports. Finally, conclusions are presented in Section VIII.

II. Related Work

We have recognized the importance of self- and peer-assessments in learning processes, as mentioned in Section I. Therefore, in this study, we design and develop a system for visualizing self- and peer-assessment data for learners to easily grasp an overview of the data at first glance. We expect that such visualization induces some awareness related to the improvement of learning ability. No studies have reported such a system so far. The system designed and developed in this study is a computer-assisted system for conducting self- and peer-assessments in the learning process. We describe studies on such a computer-assisted system below.

Personal digital assistants (PDAs) were used as the platform of a system for conducting self- and peer-assessments in one study [8]. This study explored the potential of applying mobile technology to self- and peer-assessments. The system itself is web-based. In the system implementation, a teacher and students first discuss and co-select assessment criteria or scoring rubrics, and then the teacher enters the criteria into the system. For example, the criteria could be "Oral communication", "Ways of presentation", and so on. Both the students and the teacher give scores for the criteria. Our developed system in this study also uses scores (numerical values) for assessment. However, unlike the system using PDAs, our system focuses on visualization of the scores, as mentioned above.

In addition to the system using PDAs above, many web-based systems have been used for self- and peer-assessments. A web-based system for self- and peer-assessments on portfolios was developed [13]. In this system, students perform portfolio creation, inspection, and self- and peer-assessments. The teachers review the portfolios that the students created and evaluate their learning performances. In this system, students and teachers give scores to assessment rubrics as well as comments on the assessment rubrics. In [14], a web-based system for conducting self- and peer-assessments of digital competencies among teachers was developed. Digital competencies are given as scores. In [15], a web-based system for reviewing videos recording medical communication was developed. In the experiments using the system, medical students recorded their consultations with a simulated patient and then uploaded the video to the web-based system. Then, they conducted self- and peer-assessments of the recorded videos. Specifically, they marked and annotated positive and negative events in the recorded videos. In this case, self- and peer-assessments were given as texts.

Finally, although it is not a computer-assisted system for the self- and peer-assessment system, a social network service was used to introduce, explain, and deliver self-assessment tasks to students [16]. This interesting approach was presented to motivate students to participate in self-assessment in learning processes.

Not only in the existing systems described above, most mechanisms to allow people to conduct self- and peer-assessments would now be computer-assisted. In addition, as in the social network service used in [16], new emerging technology will actively be utilized for systems related to self- and peer-assessments in the future. As the marking and annotation of recorded videos, new ways for assessment will be utilized as well. In this study, we focus on visualization of self- and peer-assessment data in consideration of human cognition and awareness. This consideration of human cognition and awareness is the main originality of this study.

The contents from Sections I to V in this paper are similar to our previous conference paper [19]. Here, we add the results of experiments in which people actually used the system for visualizing self- and peer-assessment data.

III. Designing a System for Visualizing Self- and Peer-assessment Data

A. Concept

The purpose of the system designed here is to make it easy for people who are not statistics experts to become aware of data that would help them to improve themselves. self- and peer-assessments are collected as the data. Self-assessment is useful because people are forced to look back at what they were. However, self-assessment has less objectivity. Assessment from others is also subjective, but would bring some objectivity as the amount of assessment data increases. In addition, assessment from others often includes information that a person had not recognized about him or herself. Visualization of the self- and peer-assessment data considered here helps people find such information not recognized by the people themselves. Our visualizations of self- and peer-assessment data show the differences between self- and peer-assessment results and the positions of people in a community to which a person belongs. Unlike self-assessment, the assessment from others enables a person to realize his own characteristics that he or she would not notice only by self-assessment. The positions of the people reveal those who are close or far from others in the community, so that a person might become aware of characteristics for his or her improvement by referring to the positions of others to whom the person is attracted.

In addition, we assume that people in a community who know each other well would use the system. If people who do not know each other well assess themselves mutually, the reliability of the obtained peer-assessment would be low and the assessment results would not be acceptable to the people. Thus, this assumption is quite natural. Furthermore, an appropriate amount of self- and peer-assessment data is needed for inducing the awareness of people. People cannot recognize some tendency that might relate to their awareness with too much data or too little data. Therefore, we assume the total number of self- and peer-assessment data is several hundreds. Also, we consider the burdens on people to assess

others. If the number of people as targets for peer-assessment is large, their burdens would become quite heavy.
Shneiderman's mantra, "Overview first, zoom and filter, then details-on-demand" [17], is famous in the data analysis field. It would be hard for us to understand the meaning of a large amount of data just by looking at the data piece by piece. As this mantra says, when we have a large amount of data to analyze, we should first overview the large amount of data. Then, based on the knowledge obtained by the overview, we examine the details of the data. The purpose of this study is not to analyze data but to visualize data in order to provide people with some awareness or knowledge of themselves. However, even for the purpose of this study, it would be a benefit to show an overview of data to people first to induce some awareness. In other words, it is necessary to visualize data in such a way that people can generally or qualitatively notice facts revealed by the data, for example, the fact that the self-assessment of the person concerned is quite far from assessment of the person by others. Then, a supplementary mechanism for examining details of the data should also be provided for the people. Here, it would not be good to visualize data only in such a way that people can notice facts quantitatively or in fine detail, for example, the fact that the difference between a self-assessment result of the person concerned and a assessment result of the person from another person is just one in terms of the score for a specific assessment object.

B. Design

We designed the system by using components of unified modeling language (UML), such as the use case diagram. The use case diagram for the system is shown in Figure 1. The use case descriptions for system functions, such as registering assessment data, deleting assessment data, and viewing assessment data, are also made, but are not shown here due to space limitations. The main function of the system here is to visualize self- and peer-assessment data represented as a multi-dimensional numerical vector. We concentrate mainly on the main function and make other functions simple so that they can satisfy the minimal requirements. The system has a function for collecting self- and peer-assessment data for visualization and a function for revising inputted self- and peer-assessment data. Although it would be useful for people to mutually describe reasons for giving assessment data in natural language, we do not yet provide such a function in the system. In the future, we will add the function for people to add comments or reasons for their assessment in the system. Even without this function, it is possible that people in a community who assess each other can review the visualized self- and peer-assessment data in a face-to-face manner, because it is assumed that the people know each other well.

IV. Developing a System for Visualizing Self- and Peer-assessment Data

In this section, we show our developed system according to the design described in Section III.

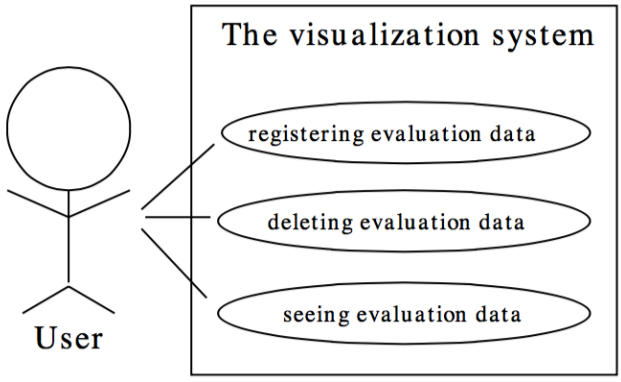

Figure. 1: Use case diagram of the designed system.

A. Perspectives of Self- and Peer-assessment

We have to determine concrete perspectives on the self- and peer-assessment to develop a system for visualizing self- and peer-assessment data. We used the assessment perspectives for "Fundamental Competencies for Working Persons" [11] defined by the Ministry of Economy, Trade and Industry, Japan in 2006. The definition of "Fundamental Competencies for Working Persons" is given as the basic abilities required for various people in the workplace and in local communities to work together. The abilities consist of three competencies and 12 competency factors, as shown in Table V-A. The number of grades for all assessment perspectives is four, in which 0, 1, 2, and 3 mean "poor", "fair", "good", and "excellent", respectively.
People who are concerned with job hunting are suitable users for the system. For example, a group of university students who know each other well and are about to start job hunting or who are now job hunting are suitable users.

B. Implementation

We implemented our design shown in Section III as a web application system. The implemented system has the screen transitions shown in Figure 2. The implemented system runs PHP 5.4.10 on the server and uses JavaScript for the clients' web browsers. Also, it uses a batch learning SOM, in which initialization of the weight values of the self- and peer-assessment data for visualization is done by principal component analysis (PCA). The reasons for using SOM for the visualization are as follows.

- It is not very difficult for users to understand how to see the visualized data by SOM. Conventional ways, such as a radar chart, are well known for visualizing data and are probably easier for users to understand how to use them in comparison with SOM-based visualization; however, even such easy methods need to come with explanations to the users about how to use them.
- Visualization by SOM would be suitable for overviewing a large amount of data compared to, for example, a radar chart.
- We can intuitively understand the differences between self- and peer-assessment results as the distance relations between them on the map formed by SOM.

Table 1: Fundamental Competencies for Working Persons.

Ability to step forward (action)	
Initiative	Ability to initiate things proactively
Ability to influence	Ability to influence and involve others
Execution skill	Ability to set goals and execute with conviction
Ability to think through (thinking)	
Ability to detect issues	Ability to analyze status quo and clarify issues
Planning skill	Ability to clarify procedures to solve issues and prepare
Creativity	Ability to create new values
Ability to work in a team (teamwork)	
Ability to deliver messages	Ability to delivery own opinions clearly
Ability to listen closely and carefully	Ability to listen to other people's opinions carefully
Flexibility	Ability to appreciate different opinions and perspectives
Ability to grasp situations	Ability to comprehend relationship between yourself and other people as well as things surrounding you
Ability to apply rules and regulations	Ability to comply with social rules and keep promises with others
Ability to control stress	Ability to deal with the original cause of stress

- Visualization by SOM reveals relations between the entire assessment data, not just between data on a particular assessment perspective. We think the relations between the entire assessment data are more important for inducing user awareness. In addition, even if users desire visualization by SOM to show the relations between data on a particular assessment perspective, the visualization can represent the relations by using different colors of the units that form the map.

- SOM would more flexibly map self- and peer-assessment data that are not in a linear relationship than would a conventional method, such as PCA.

We implemented the functions below in the screen visualizing self- and peer-assessment data (Figure 3).

- Function to visualize self- and peer-assessment data by SOM and color units of SOM by the U-matrix [18]. The U-matrix assigns a color to each unit according to the distance between the weight vector of the unit and the weight vectors of the unit's neighbors. Lighter-colored units adjacent to each other have more similar weight vectors than do darker-colored ones.

- Function to color only assessment data given by a particular assessor and also only assessment data for a particular person. This function is intended to enable users to visually easily understand the differences between self- and peer-assessment data.

- Function to color assessment data for each assessment perspective according to the assessment value. This function is intended to enable users to visually easily observe the differences between users with respect to the focused assessment perspective. Darker-colored units represent larger values for the focused assessment perspective.

- Function to show the original detailed assessment data when its corresponding data unit on the two-dimensional map formed by SOM is selected.

In Figure 3, which shows the assessment data visualized by SOM in the implemented system, the specific assessment perspective, "Ability to deliver messages", has been selected and colors of all units have been determined according to the values of the units for that specific assessment perspective. In addition, the self-assessment data of person E are emphasized in some color (red number "32" in Figure 3) and also the assessment data from others to person E are emphasized in another color (blue numbers in Figure 3). One fact that we can observe from this figure is that the assessment data of person E by others are similar to the assessment data of person D ("31") by person E. That is, what person E feels about person D is close to what persons in the community feel about person E. We can expect that due to such an experience, deep introspection and some awareness may be induced in person E.

In actual use of the implemented system, when a user enters the user's name on the top screen and then pushes the button indicating "go to the screen for assessment", the screen shown in Figure 4 is presented. On this screen, the user selects a person to assess and inputs assessment data of the selected person and pushes the button indicating "registration of assessment data". Then, the screen indicating "completion of registration of assessment data" appears. On this screen, if the user pushes the button indicating "show the SOM result", the result formed by SOM by using only the registered assessment data is presented. Meanwhile, other buttons are for deleting assessment data and for visualizing the self- and peer-assessment data by SOM on the screen for assessment. On the screen for deleting assessment data, the user can delete the assessment data of others conducted by the user as well as the self-assessment data. Just after completing the deletion, the user is notified of the completion and the screen for deleting assessment data transitions to the screen for registering assessment data. In the case that the user visualizes the assessment data by SOM on the screen for assessment, the user can select to either visualize the assessment data of a particular person or visualize all assessment data.

We confirmed that the implemented system successfully runs in the environment in which Apache 2.2.24 is used for the web server and Safari 7.0.1, Google Chrome 32.0.1700.102, and Mozilla Firefox 25.0.1 are used for the web browser (client).

V. Evaluating a System for Visualizing Self- and Peer-assessment Data

The most essential objective behind the system for visualizing self- and peer-assessment data described in Section III

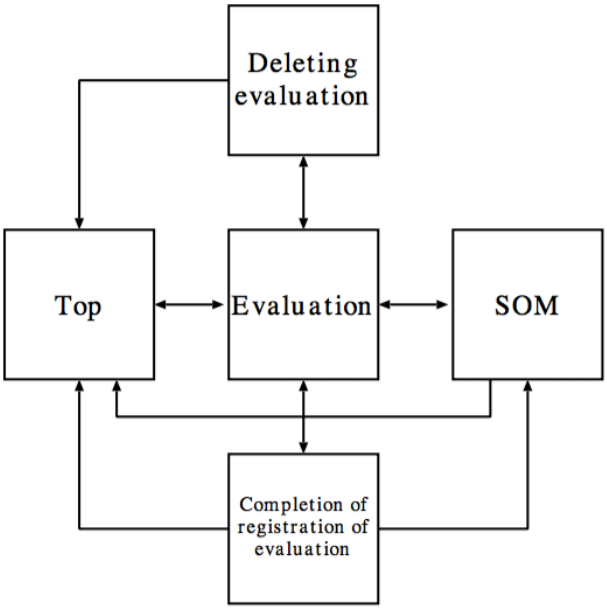

Figure. 2: Screen transitions in the implemented system.

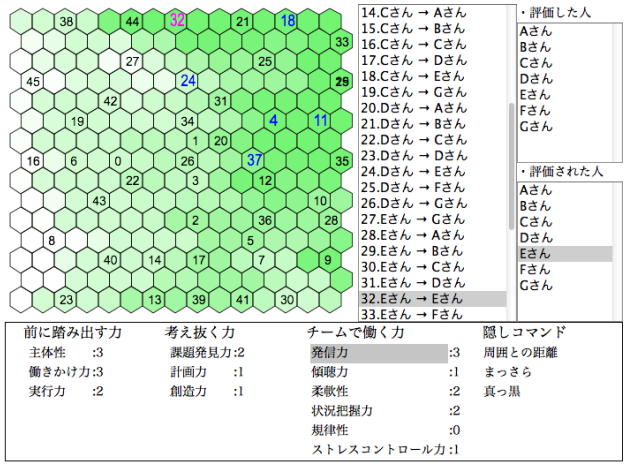

Figure. 3: Screen for visualizing assessment data by SOM (SOM screen).

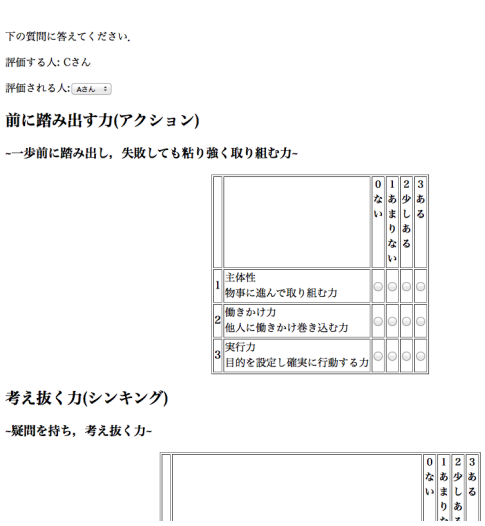

Figure. 4: Screen for assessment.

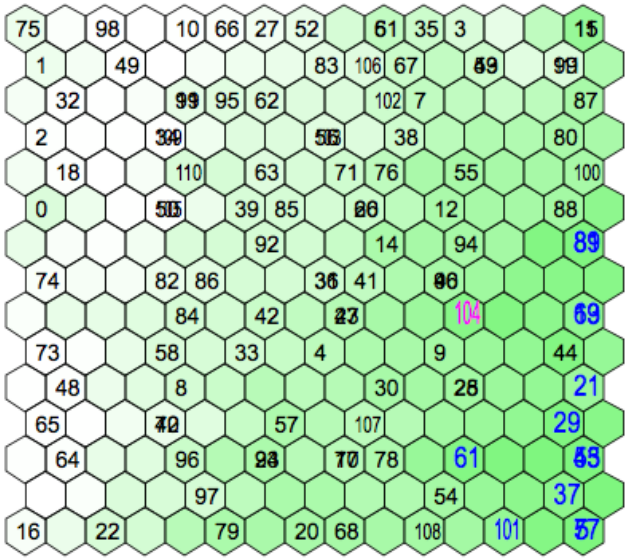

Figure. 5: System for visualizing self- and peer-assessment data by SOM.

and for the implementation described in Section IV is to induce some awareness of people by showing self- and peer-assessment data. Visualizing an overview of the relations between the self- and peer-assessment data of the people is most essential, rather than visualizing the details of each data unit. In this section, to obtain evidence to validate our system and objective, we compared our implemented system with a radar chart, which is one of the well-known conventional ways to visualize data. We conducted subjective evaluation tests and then show the results.

A. Data for Visualization

The self- and peer-assessment data used here is not "Fundamental Competencies for Working Persons" shown in Table of Section IV, which was used for the implemented system as an example. Here, people assessed each other indirectly, not directly. That is, people who come from eight prefectures in Kyushu, Japan assessed each of the eight prefectures with respect to 12 assessment perspectives on life, sightseeing, and people by a Semantic Differential (SD) method with four grades of assessment from 0 to 3. The number of people participating in this assessment was 14. The actual assessment perspectives are shown in Table 2.
The visualized assessment data by SOM and that by the radar chart are shown in Figures 5 and 6, respectively. The radar chart does not reduce the dimension of assessment data and visualizes the 12 dimensional data on the 12 assessment perspectives as a 12-sided polygon. In Figure 6, a different color on the 12-sided polygon represents different data. Both of the visualization systems using SOM and the radar chart can display only focused data, such as just one assessment data value or all assessment data for a particular assessment target. Therefore, people can observe not only differences between self- and peer-assessment data but also an exact assessment value on a specific assessment perspective.

Table 2: Impressions of each prefecture of the Kyushu district in Japan.

Life	Sightseeing	People
Food is delicious ⇔ Not delicious	Culture is impressive ⇔ Not impressive	An accent is strong ⇔ Not strong
Safe ⇔ Unsafe	Specialities are impressive ⇔ Not impressive	Can be a marriage partner ⇔ Cannot be
Convenient ⇔ Not convenient	Rich in nature ⇔ Not rich	Many good-looking men ⇔ Not many
Easy to access ⇔ Not easy	Beautiful landscapes ⇔ Not beautiful	Many good-looking women ⇔ Not many

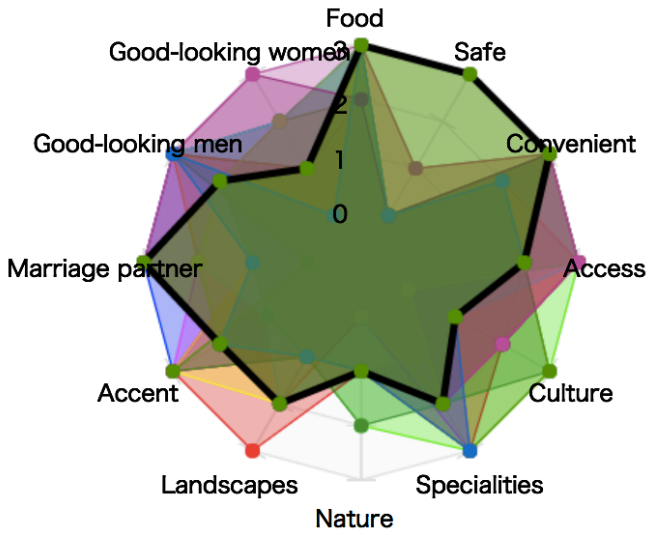

Figure. 6: System for visualizing self- and peer-assessment data by a radar chart.

B. Subjective Evaluation Test

We asked 26 test subjects, who were not the same people who generated the assessment data on the prefectures of Kyushu district, to actually use the two systems for visualizing assessment data. Then, we also asked them to conduct paired comparisons of the four comparison perspectives below, by using five assessment grades ranging from -2 to +2, in which -2 means the system using a radar chart is much better and +2 means the system using SOM is much better.

(1) Which system makes it easy to qualitatively understand the differences between a self assessment result of a prefecture from which you come and assessment results of it by others.

(2) Which system makes it easy to quantitatively understand the differences between a self assessment result of a prefecture from which you come and assessment results of it by others.

(3) Which system makes it easy to qualitatively understand the differences between assessment results of a prefecture from which you come and assessment results of prefectures from which you do not come.

(4) Which system makes it easy to quantitatively understand the differences between assessment results of a prefecture from which you come and assessment results of prefectures from which you do not come.

We assigned a specific prefecture to each of the 26 subjects, and asked each subject whose assigned prefecture was not the one from which the subject comes to conduct the paired comparisons above. The results of the paired comparisons are shown in Table 3.

Table 3: Results of subjective evaluation tests (paired comparisons) and statistical hypothesis tests (Wilcoxon signed-rank tests).

	-2	-1	0	+1	+2	statistic, T	probability, P
perspective (1)	2	4	1	9	10	73	0.00932
perspective (2)	3	8	3	7	5	155.5	0.6100
perspective (3)	3	4	2	6	11	88.5	0.02710
perspective (4)	4	8	1	8	5	164	0.7718

C. Statistical Hypothesis Tests

We applied the Wilcoxon signed-rank test to the data shown in Table 3 to examine whether a statistically significant difference existed between the two compared systems. In the Wilcoxon signed-rank test, we first calculate the statistic, T, which represents the difference between two compared data sets. Then, we obtain the probability, P, which calculates the probability of occurrence of statistic, T, by using the standard normal distribution table. If P is smaller than a given significance level, α, we can say that a statistically significant difference is found between the two compared systems with the significance level, α. We also show the results of the Wilcoxon signed-rank test in Table 3. We confirmed from Table 3 that a statistically significant difference is found with respect to perspective (1) with a significance level of 0.01, and also that a statistically significant difference is found with respect to perspective (3) with a significance level of 0.05.

D. Discussions

From the results of the Wilcoxon signed-rank test, we could confirm that our implemented system for visualizing self- and peer-assessment data is more useful for comparison perspectives (1) and (3) in Section V-B than the system using a radar chart for visualization. SOM used in our implemented system arranges data close to each other in the original 12-dimensional space closely in the 2-dimensional space to be visualized. This feature would help the subjects understand the difference between data qualitatively. Perspectives (2) and (4) are related to seeing the differences numerically or quantitatively. A numerical value here means an assessment value for each assessment perspective and is represented by the four steps of assessment from 0 to 3. In the visualization by SOM, the numerical differences between data are expressed by color differences of the units. For example, in the case that most assessment values are close to each other, it might be hard for people to understand numerical differences as color differences. To improve this feature of our system, it is possible to realize the function such that a corresponding radar chart appears by clicking on data in the 2-dimensional space formed by SOM.

Figure. 7: Screen for inputting peer-assessment data for educational report

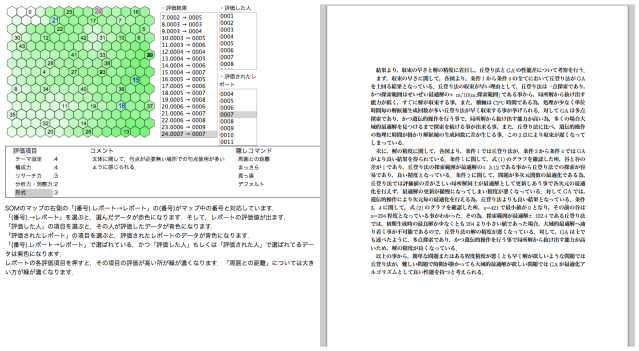

Figure. 8: Screen for viewing self- and peer-assessment data visualized by using SOM.

VI. Visualizing Data of Self- and Peer-assessments of Reports

In Section V, we showed that SOM is more useful than a radar chart for inducing awareness in learners. In this section, we describe the system developed for the examination mentioned in the next section. The next section describes the results of examinations to determine whether the system for visualizing self- and peer-assessment data indeed induces awareness of factors related to the improvement of learning ability of the learners. The developed system visualizes data of self- and peer-assessments on reports written by learners about a given topic. In Section IV, we developed the system in which "Fundamental Competencies for Working Persons" were adopted as an example of assessment targets. In Section V, we developed the system in which home prefectures were adopted as an example of assessment targets. In this section, we introduced new assessment targets. For this purpose, we implemented new system functions.

The screen of the developed system for inputting self- and peer-assessment data is shown in Figure 7 and that for referring to the self- and peer-assessment data visualized by SOM is shown in Figure 8.

For the assessment of reports, we added a function to preview reports so that the learners could assess them easily (Figure 7 right, Figure 8 right). We thought that the function to preview reports would reduce the burden of peer assessments on learners. We also thought that referring to a report together with the self- and peer-assessment data would be useful for obtaining awareness.

Assessment Perspectives	Detail	0.bad	1.poor	2.fair	3.good	4.excellent
1.Theme Selection	From the given data, is the theme selection appropriate for the report?	○	○	○	○	○
2.Composition Skill	Accoding to the theme setting, is the text developed and led to the conclusion properly?	○	○	○	○	○
3.Inquiry Capability	Is there no contradiction between data and conclusion?	○	○	○	○	○
4.Analytical Skill	Is it pulled out and grasped something?	○	○	○	○	○
5.Format	Is it not deviated from the number of characters limit, not too small, broken appropriate paragraph and writtern in the appropriate style and expression to the report?	○	○	○	○	○
6.Comment	Comment a point that was particular worrisome.					

Figure. 9: Assessment perspectives and comment space.

In addition, for the purpose of the assessment of reports, we added a function to enable people to assess reports anonymously. In the peer assessment of reports here, we adopted anonymous assessments for the learners, because we thought that if people use their real names when assessing reports, the assessment results would highly depend on the relationships between the people and the assessments might not be purely about the reports they wrote. Therefore, in the developed system here, we randomly assigned two-digit numbers as identifiers of the learners who conducted the self- and peer-assessments.

We considered five perspectives for the assessment of reports: "theme selection", "composition skill", "inquiry capability", "analytical skill", and "format". Each assessment perspective was graded on a five-point scale. Therefore, the self- and peer-assessment data, which were many five-dimensional data, were mapped to a two-dimensional space by SOM. Also, we added a function to give comments, including reasons for the assessment to the corresponding report. (Assessment form shown in Figure 8.)

VII. Experiment for Evaluating the Effect of the Visualization

A. *Experimental Flow and Condition*

Eleven students (five undergraduate students and six master students) in the laboratory of the authors participated in the experiment. We requested the 11 participants to write a report on the examination of optimization results obtained by two optimization methods, a genetic algorithm and a hill-climbing method. Note that the 11 participants had enough

knowledge to understand and examine the results. We then requested them to conduct self- and peer-assessments for the reports they wrote.
After the self- and peer-assessments, the 11 participants reviewed the self- and peer-assessment results by using the system. Finally, we requested them to answer a free descriptive questionnaire, from which we could obtain 10 answers. The questions were "What were you aware of regarding improvement of the report you wrote?", "What made you aware of the improvement?", and "If you became aware of the improvement points from the visualization of the self- and peer-assessment data, please tell us which specific data or specific relation between data made you aware of those."

B. Results and Discussions

From the results of both the self- and peer-assessments using the system and the questionnaire, we consider the functions that induced awareness of the improvement of the reports from the participants, how the participants were aware of the improvement points by using the functions, and the problems of the system that should be solved.
Most participants answered that concrete values of the five perspectives for assessing a report were useful for considering the improvements of reports. Most students focused on perspectives that were given small assessment values by others for their reports, and then compared their reports to others' reports that were given larger values for the same perspectives. For example, some participants became aware that the format of the report could be improved by looking at the results of the self- and peer-assessments, as shown in Figure 10. In Figure 10, the map formed by SOM and the units in the map were colored according to the values of the "format" perspective. A darker color means a larger value. The number "20" in the map is the self-assessment data of a participant's report and the numbers "11", "14", and "17" are the peer-assessment data of the participant's report from others. We can observe from the figure that the assessment values for the "format" perspective of the participant's report are not good; that is, the corresponding units have light colors. Consequently, this participant could obtain clues on how to improve the report format by referring to reports with larger assessment values for the "format" perspective.
Several participants answered that visualization of the self- and peer-assessment data by using SOM was useful for obtaining awareness for the improvement of reports. One participant became aware that some reports, whose positions in the SOM map were close to the positions of the reports of other participants, were indeed similar to each other in terms of composition, contents, conclusion, and so on. Another participant mentioned that the reasons for the assessment of others' reports being close to the report of the participant were useful for considering improvements of the report. Also, participants would be able to find good and bad points more easily in others' similar reports than in their own reports, because people can usually criticize others' reports more objectively than their own reports.
In addition, one participant became aware that the positions of the assessment to the report of the participant from others in the map were separate from each other; that is, the assessment depended on the participants. Figure 11 shows

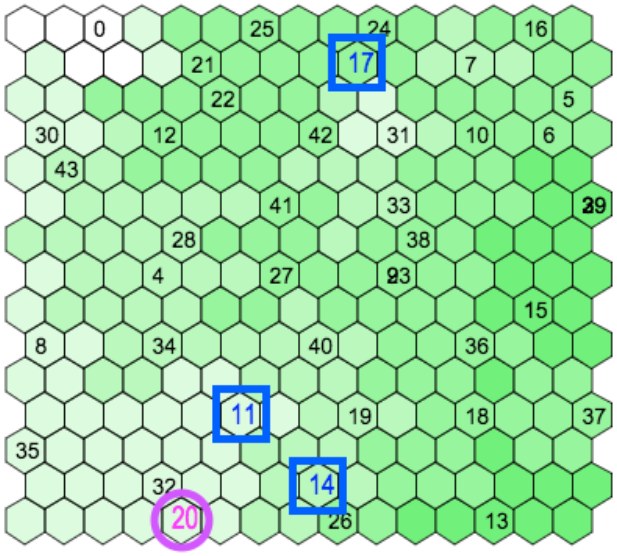

Figure. 10: SOM colored for the perspective "format".

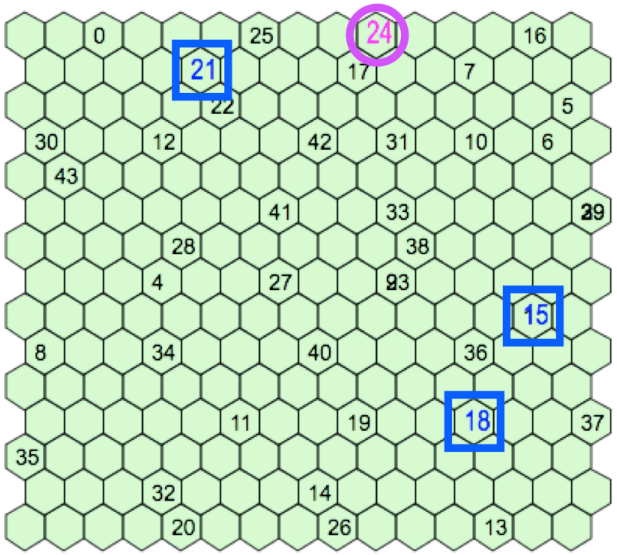

Figure. 11: Example of self- and peer-assessment data separately distributed.

that map. In the map, the number "24" is the self-assessment data for the report of the participant and the numbers "15", "18", and "21" are the assessment data for the reports of others. Due to this awareness, the participant further became aware that the participant could obtain clues to improve the report by examining other's reports whose peer-assessment data were densely distributed in the map. Figure 12 is an example of such a map. In the map, the number "16" is the self-assessment data for the specific report and the numbers "7", "10", and "13" are the peer-assessment data for the same report.
As mentioned above, the answers from the participants showed that visualization of the peer- and self-assessment data could induce awareness of a factor related to improvement of the reports from other participants. However, the number of participants who obtained awareness was not many. If we explained how to use the map of the self-

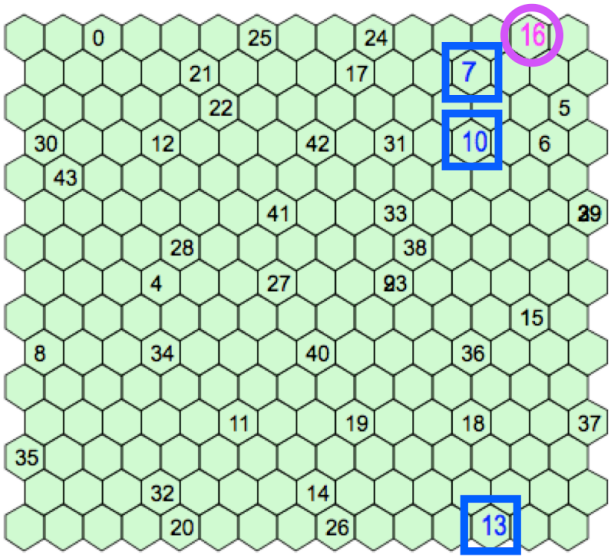

Figure. 12: Example of the self- and peer-assessment data densely distributed.

and peer-assessment data formed by SOM more specifically, for example, by giving examples on how to comprehend the map, we think that more participants would have been able to obtain awareness.

VIII. Conclusions

In this study, we designed a system for visualizing self- and peer-assessment data and developed an actual system. We compared our visualization method using SOM with an existing method using a radar chart through a subjective evaluation test and a statistical hypothesis test. From the comparison results, we were able to show the usefulness of our visualization method.
In addition, we conducted an experiment in which participants used the actual developed system for validating the effect of the visualization of self- and peer-assessment data on inducing awareness related to improvement. Answers to questions about the developed system after the experiment showed that the people who participated in the experiment indeed felt that the visualization helped them obtain such awareness.
In future work, we will verify that people can actually improve their learning ability based on the awareness obtained by using the system. For the verification, we need to first request people to conduct learning and assessments repeatedly and then observe the improvement of these people.

Acknowledgment

We are most grateful to Takuro Kawamura and Shogo Yamazaki for their system development and discussions.
This work was supported by the Japan Society for the Promotion of Science through a Grant-in-Aid for Scientific Research (C) (25330289).

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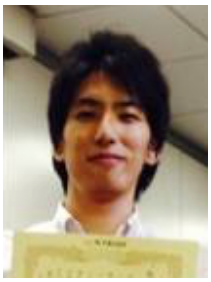
Author Biographies



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