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ENHANCING SCIENTIFIC COMMUNICATION BY COORDINATING SPOKEN EXPLANATIONS WITH VISUAL PPT PRESENTATIONS

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ABSTRACT

Language usually refers to the system of spoken words and written symbols used in human communication. In the field of science and engineering, the communication process contains other elements, including formulae, figures, and graphs. These elements convey specific meanings to people in the same discipline; just as in ordinary language, there exist established conventions as to how they should be used. Viewed from this perspective, formulae, figures, and graphs can be regarded as "the language of science and engineering." Nowadays, PowerPoint (PPT) has become the most common tool for communication, education, and research presentations in science and engineering. PPT allows information to be presented visually, in an unprecedentedly colorful and dynamic way with abundant detail. Consequently, the language of scientific communication has evolved from an oral to a visual level. It is assumed that this "visual language" can compensate for inadequate speaking ability. This study addresses the question of how to make full use of the "visual language" of PPT in research presentations. Questionnaires were designed to evaluate the PPT presentations of students in water environment laboratories. Data were collected and analyzed using statistical and quantification methods. The results show that presenters with little speaking ability can improve their success rate by focusing on communicating one main point and the logical progression of ideas when planning PPT slides for a presentation. In addition, for all presenters, it is crucial to coordinate PPT slides with an accompanying spoken explanation.

KEYWORDS: Scientific Communication; Language of Science; Visualization; Quantification Analysis

INTRODUCTION

Background

Communication is a process that uses various techniques to exchange information between individuals or within a group of people[1][2]. Science and engineering students usually communicate by talking, sometimes with visual aids; in most cases, communication involves a combination of the two techniques[3]. For example, a student or a lecturer will often present an idea by writing equations or drawing sketches on a whiteboard while at the same time explaining the concept. Within the domain of science and engineering, equations and figures are symbols with particular meanings that people who share a discipline can be expected to understand. Certain rules govern the way equations should be written and figures drawn. As these equations and figures can be considered a language of science,science and engineering students have in effect two languages: the one they hear and the one they see (aural and visual languages)[4] [5].

Japanese students, especially those who study science and engineering, often find it difficult to deliver oral presentations at international conferences where English is the official language. As they spend most of their time doing calculations on the computer or performing experiments, they have little time to improve their spoken English. As a result,

they often receive poor evaluations for research that is actually very well done[6].

At the same time, the visual language mentioned above has developed remarkably during the past twenty years [7]. Computer-based PPT has replaced relatively primitive tools, such as whiteboards, slide projectors, and OHPs (overhead projectors). As a result, once colorless figures and graphs have become colorful; a static and fixed visual language has become dynamic and flexible [8]. This technological evolution parallels the transition from radio to television. When listening to the radio, we must focus on language to take in all of the information being communicated; when we watch TV, the situation is quite different, as vivid onscreen images make it relatively easy to understand what is going on. Visual messages are apparently much more effective than audio messages in the communication process [9]. Given the widespread use of PPT and computers, oral presentations no longer rely on the spoken word as they did previously. This change can help to compensate for a presenter's inadequate speaking skills. It should also be possible to improve oral presentations by sensibly combining the spoken and visual languages.

Purpose

First, this study attempts to verify the hypothesis that the effective use of PPT can enable presenters who do not speak English well to nevertheless give good presentations. Second, this study aims to identify the key factors and general qualities that characterize good PPT presentations, in order to offer innovative advice to all students, and in particular to those whose spoken English is poor.

METHODOLOGY

Participants and Context

Certain requirements must be met when selecting research objects. First, to simulate actual presentations at an international conference, sample English oral presentations are necessary. In addition, the presenters must be science or engineering students. Second, to ensure that the research process can be repeated continuously, there should be a large number of samples, including both good and bad examples. Third, the cooperation and feedback of an audience are indispensable.

Given the requirements above, the Water Environment Unit of the Tokyo Institute of Technology was chosen as a study site. This unit consists of three laboratories that include about 30 undergraduate, Master's degree, and doctoral students. The majority of these students are Japanese. International students from China and Thailand make up about one-third of the group.

In the Water Environment Unit, a joint seminar is held once a week. During each seminar, several students are asked to make ten-minute PPT presentations to introduce their research. These presentations are followed by a short discussion between the presenter and the audience. The whole seminar is video-recorded.

Procedures

A questionnaire survey was the main method used in this research project. Audiences used questionnaires to evaluate seminar presentations; the completed questionnaires were used to investigate the correlation between presentation pattern and presentation effect. The survey was carried out in two stages. The results of the first stage provided content for the second stage. Finally, video recordings of the presentations were analyzed to identify techniques that could be used by

students with inadequate oral English to achieve effective presentations.

Step 1

Evaluation of the Basic Elements Involved in an Oral Presentation

In the first stage, the basic elements of a presentation were classified into the following general categories: *A) Structure, B) PPT file, C) Speaking*, and *D) Gestures.* A final element, *E) Overall impression*, was also evaluated.

A questionnaire was accordingly designed to discover how these basic elements influence an audience's impression of presentation excellence. The data was initially analyzed using Principal Component Analysis to identify the most important factor among A, B, C, and D. To minimize the impact of individual differences relating to nationality, grade, study theme, and English proficiency,it was necessary to separate the students into groups for further study. Cluster Analysis was therefore applied to classify the students in accordance with their similarities. The two methods were then combined for further analysis.

Step 2

Breakdown Analysis of the PPT file

The first step revealed that *B (PPT file)* was the most important component in a presentation. To explore this finding further, in Step 2, the PPT file was broken down into the following 8 aspects: *Main point, Compactness, Symbolism, Relevance, Consistency, Continuity, Dynamism,* and*Viewability*. To correlate these factors and determine which ones were most influential, Factor Analysis was applied to extract the core aspects of the PPT file.

Step 3

Reevaluating Video Recordings Using Comprehensive Indexes

The final stage aimed to identify key points that could improve the presentations of speakers with poor spoken English. At the same time, this stage attempted to identify the key qualities common to all good presentations. Comprehensive indexes of the criteria for evaluating oral presentations were created using the findings from Steps 1 and 2. These indexes were used to reevaluate the presentation videos. Quantification Ⅱ was then applied to analyze the data collectively rather than individually. Since each student had at least two chances to deliver a presentation during the research period, and most of them made progress, their performances were compared both vertically and horizontally to isolate factors that caused presentations to improve.

DATA ANALYSIS AND DISCUSSIONS

The key Element Influencing PPT Presentations

During the initial stage (June–August 2014), our goal was to identify the most important factor in determining the quality of a presentation. Presentations include four basic elements, as Alley M. has pointed out: speech, structure, visual aids, and delivery [10]. Using an evaluation sheet, both basic factors and the overall performance were evaluated, as follows:

- *Structure: the main point and logic of the presentation should be clear.*
- *PPT file: visual information should be easy to see (font size, color, arrangement of figures and graphs).*
- *Speaking skills: this mainly refers to proficiency in spoken English.*

- *Involvement with the audience:*
- *This refers mainly to gestures and other forms of interaction with the audience.*
- *The audience's overall impression of the presentation*
- A seven-point grading scale was adopted(1: poor, 4: average, 7: excellent).

At this stage, 31 presentations were used as samples. The average value of each item was calculated for each presenter and used as the input data for data analysis (Table 1).

Table 1.Basic Presentation Element Scores

Sample	A. Structure	B. PPT	C. Speaking	D. Gestures	E. Overall evaluation
S1	4.903	5.258	4.387	4.290	**4.516**
S2	5.290	5.452	5.677	5.032	**5.226**
S3	5.387	5.258	5.161	4.742	**5.161**
S4	4.742	4.419	4.871	4.484	**4.484**
S5	5.065	5.355	5.097	4.806	**5.000**
S6	5.355	5.452	5.516	5.452	**5.387**
S7	5.414	5.276	5.517	4.897	**5.310**
S8	5.310	5.138	4.621	4.621	**4.828**
S9	5.172	5.655	6.069	5.414	**5.448**
S10	5.321	5.448	5.793	5.138	**5.379**
S11	5.690	5.793	5.931	5.138	**5.690**
S12	4.926	5.037	5.444	4.720	**5.071**
S13	5.259	5.185	5.407	5.000	**5.161**
S14	4.593	4.370	4.889	4.500	**4.554**
S15	5.481	5.296	5.000	5.154	**5.286**
S16	5.379	4.607	6.074	5.538	**5.414**
S17	4.793	4.414	5.276	4.448	**4.533**
S18	5.222	5.423	5.556	5.269	**5.300**
S19	5.643	5.704	5.704	5.654	**5.733**
S20	5.241	4.897	5.483	4.724	**5.000**
S21	5.577	4.923	6.077	5.038	**5.577**
S22	5.462	4.538	5.385	4.808	**5.500**
S23	5.731	5.885	6.115	5.538	**5.904**
S24	4.538	4.077	4.077	4.192	**4.058**
S25	4.981	4.673	4.808	4.500	**4.769**
S26	4.900	4.833	5.200	4.500	**4.933**
S27	4.700	4.467	4.900	4.767	**4.800**
S28	4.667	4.633	3.767	4.367	**4.333**
S29	4.867	5.000	4.800	4.767	**4.833**
S30	4.400	4.367	5.000	4.367	**4.467**
S31	4.759	4.655	5.000	4.690	**4.897**

Principal Component Analysis was applied to isolate the most important factor (A, B, C or D) in evaluating a presentation. Judging from the eigen value of each component, the most important principal component was the overall performance (Table 2), confirming expectations. The second most important principal component was the PPT file; the third was "Structure" and the fourth "Gestures."

Table 2: Principal Component Analysis

	Eigen vector			
Principal Component / Item	1st	2nd	3rd	4th
A. Structure	0.514	0.182	0.837	0.040
B. PPT	0.477	0.699	-0.429	-0.316
C. Speaking	0.485	-0.662	-0.127	-0.557
D. Gestures	0.523	-0.202	-0.314	0.767
Contribution Rate	**78.9%**	**11.5%**	**5.4%**	**4.2%**

Although "Speaking" was not one of the four principal components, it is certainly an important element. However, our results suggest that speaking may not be the decisive factor in a good presentation. In some cases, even though the presenters could not speak fluent English, their presentations were still considered very good.

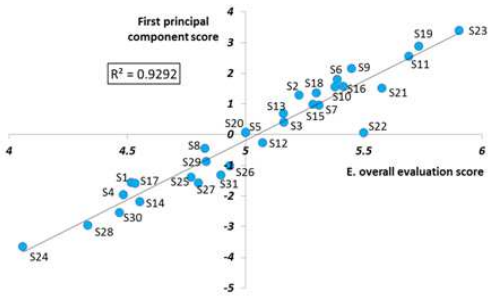

Figure 1: Correlation between the 1st Principal Component and the Overall Evaluation

Since the 2nd component was the PPT file, the most important factor (out of A, B, C, and D) was B, the PPT file. After examining the correlation between the 1st principal component and the overall impression, which agreed very well (as shown in Fig. 1), our next step was to check the correlation between the 2nd component and the overall evaluation. The influence of the 2nd principal component on the overall evaluation reflects the important role played by PPT files in presentations.

Due to individual differences between the students (including grades, study themes, and English proficiency levels), they cannot be compared directly. For this reason, Cluster Analysis was used to categorize the students into three data groups (as shown in Fig. 2), based on similar presentation scores for items A, B, C and D [11].

The correlation between the 2nd principal component and the overall evaluation was then checked. It can be seen in Fig. 3 that, within each cluster, the 2nd principal component score was positively related to the overall evaluation. That is to say, the higher a PPT file score was, the better the overall evaluation was likely to be.

There were some exceptional cases. Presenters 1, 4, and 28 had well-made PPT files but received very low overall evaluation scores. Presenters 16, 21, and 22 had poor PPT files but received high presentation scores. A review of these presentations revealed that presenters 1, 4, and 28 had such poor spoken English that their speaking scores were the lowest in the group. Presenters 16, 21, and 22 were international students who spoke English every day; their speaking scores were

therefore very high. These factors are likely to have contributed to the overall evaluation scores.

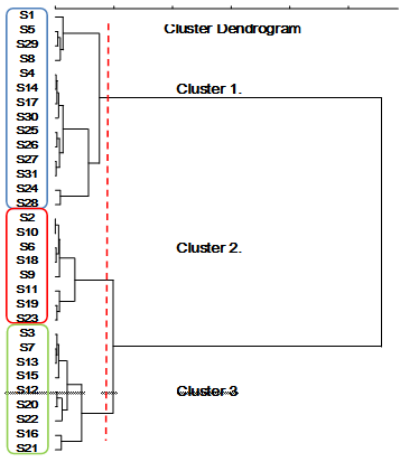

Figure 2: Cluster Analysis Result

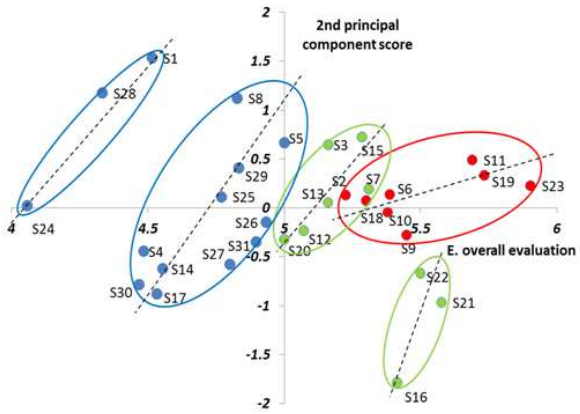

Figure 3: Correlation between the 2nd Principal Component and the Overall Evaluation

THE MOST INFLUENTIAL FACTORS IN A PPT FILE

Having confirmed that the PPT file was the most important factor in a presentation, during the next stage of the project (October–November 2014), the PPT file was broken down into its components to isolate the most influential factors. In accordance with their functions [12], the following 7 aspects of PPT files were analyzed (see below). The PPT and presentation were then evaluated as a whole.

Eight key aspects of a PPT file

- *The main point of the presentation is displayed onscreen.*
- *Compactness: points are displayed using key words instead of crowded text.*
- *Symbolism: the explanation is presented symbolically and made to appear concrete.*

- *Relevance: the logical progression of ideas is clearly presented, in particular through chronological order and cause and effect.*
- *Consistency: the PPT slides and spoken explanations are well coordinated.*
- *Continuity: the transition between slides promotes continuous understanding.*
- *Dynamism: animation is used effectively.*
- *Viewability: the font sizes, colors, figures, and graphs are easy to see.*
- *Comprehensive evaluation of the PPT file*
- *Overall impression of the presentation*

A seven-point grading scale was applied (1: poor; 4: average; 7: excellent).

Table 3: Factor Evaluation Scores for PPT Files

Sample	Main Point	Compact	Symbolism	Relevance	Consistency	Continuity	Dynamism	Viewability	Overall PPT Score
S1'	4.829	5.229	4.914	4.857	5.429	4.857	4.886	4.943	**5.029**
S2'	5.343	5.086	5.486	5.286	5.371	5.143	6.257	5.429	**5.657**
S3'	5.229	4.571	4.429	4.800	5.257	4.829	4.429	4.543	**4.829**
S4'	4.857	4.886	4.765	4.829	5.143	4.714	4.143	4.800	**4.771**
S5'	5.531	5.156	4.781	5.188	5.813	5.188	4.094	4.938	**5.281**
S6'	5.438	5.156	5.188	5.125	5.094	5.000	4.469	4.844	**5.125**
S7'	5.313	4.781	5.219	5.188	5.344	5.031	4.594	4.719	**5.125**
S8'	5.375	4.844	5.406	5.188	5.094	5.125	5.906	4.750	**5.313**
S9'	5.406	5.219	5.125	5.031	5.094	4.938	5.625	5.250	**5.438**
S10'	5.355	5.065	5.194	5.355	5.484	5.032	4.581	4.387	**5.097**
S11'	5.563	5.531	5.250	5.313	5.469	5.406	5.063	5.063	**5.531**
S12'	5.677	5.323	5.129	5.258	5.387	5.097	4.484	5.194	**5.290**
S13'	5.406	5.406	5.406	5.219	5.375	5.063	5.219	5.031	**5.438**
S14'	5.438	5.125	5.375	5.375	5.219	5.125	4.969	5.031	**5.219**
S15'	5.188	4.719	4.844	4.844	5.188	4.875	4.344	4.563	**4.781**
S16'	4.606	4.697	4.606	4.606	4.818	4.636	4.303	4.394	**4.485**
S17'	4.938	4.938	5.000	4.781	4.688	4.563	4.438	4.500	**4.750**
S18'	5.281	5.125	5.438	5.188	5.281	4.938	4.938	5.031	**5.344**
S19'	5.000	4.935	4.806	4.774	4.839	4.484	4.452	4.774	**4.806**
S20'	5.032	4.581	4.774	4.903	5.000	4.935	4.387	4.323	**4.968**
S21'	5.172	5.103	5.172	5.034	4.931	4.828	4.724	4.621	**4.931**
S22'	5.531	4.625	5.250	5.219	5.500	5.281	4.750	4.938	**5.281**
S23'	4.788	5.152	5.000	4.788	5.061	4.879	4.424	5.152	**4.909**
S24'	5.406	5.031	5.000	5.156	5.250	5.094	4.875	4.750	**5.063**
S25'	5.212	5.091	4.788	4.970	5.152	4.970	5.000	5.091	**5.061**
S26'	5.485	5.121	4.879	5.121	5.485	5.152	4.697	5.091	**5.212**
S27'	5.303	5.152	5.030	4.909	5.364	4.939	4.485	4.939	**5.061**

Table 3 shows the original 2nd stage data; the 8 elements listed have some common features. Factor Analysis has been used to extract the core elements of the PPT file and to consolidate the 8 elements into a smaller set of factors with no loss of information[13]. The results are shown in Fig. 4. The first factor incorporates Relevance, the Main Point, Continuity, and Consistency; the second factor incorporates Symbolism and Dynamism; and the third factor incorporates Visual Effect and Compactness.

These three factors can be regarded as three new parameters for assessing the quality of a PPT file. The 1st factor stands for the content of the PPT file (the main point, and the logical progression of ideas). The 2nd factor relates to the impact and effectiveness of the animation; the 3rd factor stands for the audience's visual experience, in other words, viewability.

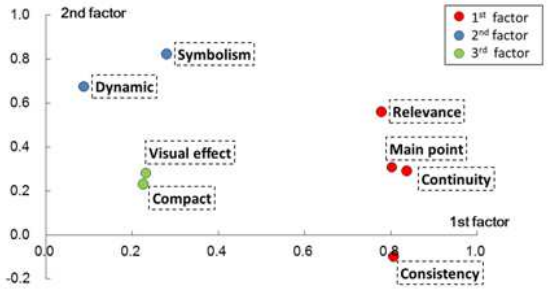

Figure 4: Factor Load after Varimax Rotation

ANALYSIS OF VIDEO RECORDINGS OF SEMINAR PRESENTATIONS

Quantification Ⅱ Analysis with Comprehensive Indexes

Thus the general correlation between the basic factors and presentation excellence was investigated. Drawing on the results of steps 1 and 2, the evaluation items were modified and comprehensive presentation indexes were created:

- Important information is highlighted
- Good continuity
- Concrete/Symbolically expressed explanation
- Viewability
- Speaking skills
- Coordination of speaking and PPT
- Interesting
- Overall evaluation of the presentation

It is worth mentioning that the primary purpose of a scientific presentation can be to inform, persuade, inspire, or entertain; in most cases, it is a combination of several purposes[10]. A review of the video files showed how important it was for an audience to consider a PPT file or presentation interesting; for this reason, G ("Interesting") was added to the list of indexes.

Using the indexes above to review videos enabled us to identify the qualities that characterized good presentations. Rather than analyzing individual presenters, the data was analyzed collectively and qualitatively. As the students had many different attributes, Hayashi's Second Method of Quantification (Quantification Ⅱ) was applied to ensure statistically significant results[14].

The presenters' performances were classified into 3 categories: 1, poor; 2, average; 3, excellent. Items A, B, C, D, E, F, and G were set as variables X1, X2, X3, X4, X5, X6, and X7 respectively. H corresponded to the Y variable. The results are shown in Table 4.

Table 4: Quantification Ⅱ Analysis

Item	Variable	Partial Correlation Coefficient	
		Axis 1	Axis 2
A. Important information highlighted	X1	0.505	0.415
B. Good continuity	X2	0.051	0.333
C. Concrete/symbolic representation	X3	0.289	0.402
D. Viewability	X4	0.554	0.375
E. Speaking skills	X5	0.343	0.145
F. Coordination of speaking and PPT	X6	0.414	0.103
G. Interesting	X7	0.233	0.207

Axis 1 stands for the relationship between categories 1 and 2 (poor and average presentations). Similarly, Axis 2 stands for the correlation between average and excellent presentations. Judging from the partial correlation coefficient (Table 4), it is clear that for Axis 1, the influence order of the 7 factors is:

X4 > X1 > X6 > X5 > X3 > X7 >X2 (in other words, D > A > F > E > C > G > B)

For Axis 2, the influence order is:

X1 > X3 > X4 > X2 > X7 > X5 > X6 (in other words, A > C > D > B > G > E > F)

From the results above, the following points can be inferred:

- *Important information is highlighted* and *D. Viewability* are the most influential factors on both Axis 1 and Axis 2. In other words, students wishing to improve their presentations should highlight the most important information. PPT slides should be compact and easy to read.
- On Axis 1, F is quite influential. One difference between poor presentations and average ones is that poor presenters do not use gestures or actions to connect their spoken commentary with the PPT slides, for example by pointing at the screen while talking. Likewise, on Axis 2, factor C is very influential; another difference between average and good presentations is that good presenters make use of animation to enliven the information, so that ideas can be more effectively conveyed.

Table 5: Quantification Ⅱ Analysis (*Speaking Skills* Excluded)

Item	Variable	Partial Correlation Coefficient	
		Axis 1	Axis 2
A. Important information highlighted	X1'	0.509	0.404
B. Good continuity	X2'	0.095	0.385
C. Concrete/symbolic representation	X3'	0.127	0.387
D. Viewability	X4'	0.387	0.411
F. Coordination of speaking and PPT	X5'	0.319	0.090
G. Interesting	X6'	0.167	0.261

In order to identify techniques that can compensate for poor speaking ability, item *E (Speaking)* was eliminated and the Quantification Ⅱ procedure was carried out again. The results are as shown in Table 5.

On Axis 1, A > D > F > G > C > B

On Axis 2, D > A > C > B > G > F

In other words, a presenter who speaks poorly should make sure the main point and key pieces of information are impressive and clearly displayed in the PPT slides.

Comparison of Two Rounds of Presentations

As time passed, the participating students improved their delivery to some extent. One reason may be that presentation content improved as the students' research progressed. In addition, after listening to the presentations of other speakers, some students may have adopted successful techniques used by others in order to improve their own presentations. This sort of change is reflected in the overall evaluation score.

During the research period, each student had at least two chances to make a presentation during the joint seminar. After two rounds of presentations, the overall evaluation scores of the 25 students were compared. Fig. 5 shows the comparison results. The blue dots represent the initial presentation scores, which are listed in ascending sort order. The red dots show the corresponding second presentation scores. The bar graphs underneath show the differences between the two rounds. It is easy to see from the average score that student performances improved in the second round. A review of the video records confirmed that their spoken English had not improved much.

Out of all of the students, presenters 5 and 6 made the most remarkable progress. Comparing their performances in the 1st and 2nd rounds, it was found that both had improved their PPT files in the 2nd round. Student 5 initially presented PPT slides that were covered with equations and text and used no animation. In the second round, these PPT slides were simplified, and included both key words and animation. Student 6 initially presented PPT slides that were simple and crude, containing only graphs; there was no connection between sections of the argument, and the main point was difficult to grasp. As a result, the audience felt lost. One month later, this student's PPT file featured key words and guiding animation. By contrast, student 25 initially presented a very well designed PPT and interacted well with the audience. In his second presentation, the PPT file was uninteresting, and included only graphs and sentences.

Presenter 24 did quite well in both rounds. Not only were his PPT files the best designed, his presentation was also well organized, with clear main points. His appropriate use of animation engaged audiences and made his explanation very concrete.

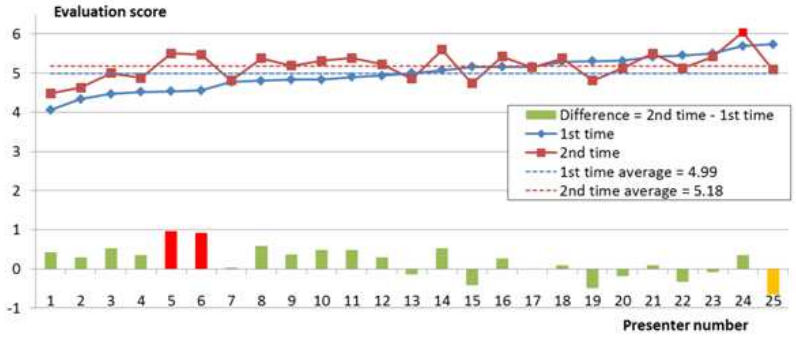

Figure 5: Comparison between the Two Rounds of Presentations

CONCLUSIONS

- The *PPT file* is the most influential of the four basic elements in a research presentation, which includes *the structure* (main point and logic), *the visual aids* (PPT file), and the *speaking* and *gestures*.
- Eight aspects of the PPT file have been analyzed, as follows: *Display of main points in the slides, Compactness, Symbolism, Relevance, Consistency, Continuity, Dynamism, and Viewability.* These 8 items have been consolidated into three factors using Factor Analysis. The first factor relates to the content of the PPT file—whether the main points and the logical sequence of ideas in the presentation are clearly displayed in the PPT slides or not; the second factor involves the effective use of animation. It is important to use animation properly to dramatically express the presenter's ideas and to symbolize abstract concepts; the third factor is the viewability of the PPT slides. Slides that are compact and easy to read will improve PPT evaluation scores.
- When planning a PPT presentation, it is crucial to use slides to clearly present the main points and the logical progression of ideas. This is especially important for presenters whose spoken English is poor. When delivering presentations, students should focus on coordinating their spoken commentary with the PPT slides. As audiences have to mentally process the information they see and hear, PPT slides that link images and symbols with spoken words will make this process easier. The presenter should point at the screen while talking, to show which fact or idea is being discussed.

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