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An Evaluation of a Customizable Ontology-driven Language Learning Support System

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Abstract: In this paper, we investigate, from learning style perspective, the main factors that affect the learning performance of the learner while using learning support systems. An experiment was conducted to evaluate two different modes of a customizable language learning support system. Students in experimental group A, who were provided with both visual and verbal learning objects, had more difficulty to focus on study compared to those in experimental group B, who were provided with only the learning objects matching their learning style while both using the system. Moreover, 53.3% of students in experimental group A believed the type of LOs, which they preferred more and felt more comfortable with, was not the type of LOs which was more effective for their learning.

Keywords: ontology; customizable learning objects; language learning support; teaching method; learning style; evaluation

1. Introduction

One of the biggest problems in older Learning management systems, such as Moodle, is that they cannot satisfy the complicated requirements of learners, especially with regard to differences in learning abilities.

Even for a group of leaners who have the same learning objective, different learner may have individual knowledge structure, learning styles and learning habits. These individual characteristics will lead to learning abilities differences and complicated learning requirements. Therefore, simply providing the same learning materials to every student, limits the effectiveness of the system.

To address this problem, in recent years personalized or adaptive learning support has been considered in many e-learning systems (Hwang et al., 2012; Klašnja-Milićević et al., 2011; Romero et al., 2009) and have shown their effectiveness.

1.1 A Customizable Language Learning Support System using ontology-driven engine

A learning support system serves as a mediator between the learner and the learning objects (LOs). Such a system's assistance to a learner would be more effective if it could provide LOs appropriate to the learner's characteristics. Based on this perspective, a customizable language learning support system (CLLSS) intended to provide LOs according to the learner's knowledge structure, learning style and habits has been developed by Wang et al. (2013).

A course-centered ontology(i.e. an ontology based on a specific course) for the construction of domain knowledge network and a teaching method ontology describing teaching forms of specific course are built in CLLSS as the foundation for LO's metadata creation. Furthermore, CLLSS makes use of the course-centered ontology to provide learners (a) a visual representation of every knowledge point; and (b) a pedagogical approach which enables the learner to compare an unlearned knowledge point with all its related knowledge points, especially with those acquired knowledge points.

However, how reasoning mechanism in CLLSS analyzes and extracts the learner's characteristics from the learning history and how to match the types of LOs with the learner's learning habits and learning styles, still are unsolved yet. Therefore, a series of experiments in this research are conducted to examine which kind of factors affect the learning performance of the learner while using

CLLSS. Based on the results of the experiments, we intend to determine the mode and the strategy which could improve the learner's learning performance more effectively.

1.2 The teaching method ontology

Although CLLSS is suitable for any language course, a specific Japanese grammar course was chosen as a sample to evaluate the system in this research and COJG (a course-centered ontology of Japanese grammar) has been developed as the domain model for the CLLSS by Wang and Mendori (2012). In COJG, the classes (including 23 top level classes, 23 second level classes and 25 third level classes; these represent grammar concepts of the grammar course) reflect the knowledge classification and their individuals (also called "instance") represent corresponding grammar points (GPs, in total about 205 GPs).

By means of the alignment of COJG and the teaching method ontology as the metadata of LOs, CLLSS intends to customize the LOs to improve the learning performance. Therefore, as to the ontology of teaching method which might have numerous concepts, this paper only focuses on the partial which related to the grammar teaching method.

There may be no single best approach to grammar teaching that would apply in all situations to diverse types of learners. However, different approaches to grammar instruction share common features and appreciation (Hinkel and Fotos, 2002). In this research, two stages of grammar teaching are considered in the teaching ontology. The first stage is "exposure with explanation" which presents new target language data to leaners to facilitate the noticing of grammatical phenomena and then explains the grammar rules (may involving more examples) to the learners to better understand the grammar points. The next stage is "practice" which expects learners to apply grammar rules to all forms of exercises until they reach competence expansion. Apparently, the concrete contents of these two stages should be also decided by the characteristics of the course.

Although these two stages also might have numerous concepts, for the experiment in this paper we only focuses on the teaching methods shown in Table 1 as one of the foundations for LO's metadata creation (another one is the contents of COJG). LOs respectively involve two kinds of exposure with explanation (verbal and pictures with verbal) and four kinds of verbal practices and three kinds of visual practices are prepared by two expert teachers for all the grammar points. The reason why those two stages both consider the verbal and visual teaching method will be discussed with the learning style theory in section 3.Those teaching methods forms in Table 1 are intended to help to identify learners' learning habits and learning style preferences.

Table 1: The sub-concepts of grammar teaching method in teaching method ontology.

Exposure with explanation	Verbal explanation	
	Pictures or diagrams with verbal explanation	
Practice	Verbal	Transformation question
		Choice question
		Translation
		Order words to make a sentence
	Visual	Fill-in-blanks with pictures
		Anime fragment
		Singing Practice

2. The dimensions of Learning style and the results of the preparatory phase

2.1 The Learning style

During one learning process, learners visually or literally receive the information from learning objects; they reflect, reason and try to use or discuss with others; then memorize and visualize the knowledge through repeatedly practices. "The ways in which an individual characteristically acquires,

retains, and retrieves information are collectively termed the individual's learning style" (Felder and Henriques, 1995, p.21). Among the learner's characteristics that affect the learning effectiveness, learning style has been recognized as one of the important factors (Filippidis & Tsoukalas, 2009).

The widely adopted leaning style model was presented by Felder and Silverman in 1998 and revised by Felder in 2002. This model defined four dimensions of learning style: Active/Reflective, Sensing/Intuiting, Visual/Verbal, and Sequential/Global dimensions. Learners of active scale tend to understand the knowledge through active trial, discussion or by explaining it to other while learners of reflective scale tend to observe reflectively; learners of sensing scale prefer to perceive data by the senses while learners of intuiting scale prefer by accessing memories or insights; visual learner prefer that information are presented by diagrams, flow charts, pictures or films rather than in written words, which is preferred by verbal learners; sequential learners gain understanding in logically linear steps while global learner need the big picture of a subject before mastering details.

When learners are provided with the types of LOs which match their learning style preference, they normally will feel more comfortable in the learning process. This kind of comfortable learning environment would active the learning motivation.

However, it may not correspond to the style that enables learners to learn most effectively. If a LOs in well designed by expert instructor, a learner could learn effective even the type of this LO does not match her/his learning style. Also the learning effectiveness can be affected by other factors such as the learner's learning habit.

Furthermore, when given a variety of types of LOs by e-learning systems, learners usually struggle to make the choice between the motivation and effectiveness and some of them even get confused. The results of the experiment in this paper also confirm this point.

Assume one learning support system organizes the learning objects based on the learning style theory mentioned above, among the following three ways which is the best strategy to balance the learner's motivation and learning effectiveness?

(1) Present all types of LOs and let the learner make their decision.
(2) Present the LOs whose types match the learner's learning style.
(3) Suggest types of LOs that were most frequently opened, based on the learning history.

Or maybe the most suitable way is considering the combination of the learning style and learning history? If so, how to combine them will be another question.

To find out the answers for determining the strategy of CLLSS, a series of experiments in this research is designed. In the experiment of this paper, we only focus on the Visual/Verbal dimension of learning style. Therefore, in the teaching method ontology, the two stages of grammar teaching both include visual and verbal forms as the first-level sub-concepts as shown in Table 1.

2.2 The ILS Questionnaire results of the preparatory phase

In the preparatory phase, a questionnaire was conducted in 3 Chinese universities with 183 undergraduate students in the Japanese major for collecting learning style distribution data.

The measuring tool adopted in this phase was a questionnaire written in Chinese, translated from the Index of Learning Styles (ILS) questionnaire of 44 questions (Soloman and Felder, 2001). The ILS questionnaire was designed based on the Felder-Silverman learning style model (1988, 2002) mentioned above. All the participants including 78 male and 105 female students were voluntarily to fill in this questionnaire. The results of the learning style questionnaire are shown in Table 2.

According to Felder and spurlin (2005), each learning style dimension has associated with 11 force-choice items, with each option (a or b) corresponding to one or the other category of the dimension (such as active or reflective). Given visual/verbal dimension as an example, based on the answer of its related 11 items, participant would be identified as having strong, moderate or mild preference for visual or verbal. Learner with strong or moderate preference for one category normally is stably exhibiting consistent learning behavior. Conversely, learner with mild preferences would be expected to shift their preference in learning activities readily.

As shown in Table2 (Dimension 3: Visual/ Verbal), 20.2% of student are strong visual learners, who strongly prefer that information be presented visually, and 30.1% are moderate visual learners, while only 1.6% of student are strong verbal learner who strongly prefer spoken or written explanations to visual presentations, and 6% are moderate verbal learner .Meanwhile, 42.1% of

students with mild preference for visual or verbal are fairly well balanced in the dimension of Visual /Verbal.

Table 2: The results of the learning style questionnaire.

Learning style	The number (and percentage)of Students in every scale					
Dimension 1: Active/ Reflective	**Strong Active**	**Moderate Active**	**Mild Active**	**Mild Reflective**	**Moderate Reflective**	**Strong Reflective**
	5 (2.7%)	28 (15.3%)	55 (30.1%)	56 (30.6%)	31 (16.9%)	8 (4.4%)
Dimension 2: Sensing/ Intuitive	**Strong Sensing**	**Moderate Sensing**	**Mild Sensing**	**Mild Intuitive**	**Moderate Intuitive**	**Strong Intuitive**
	19 (10.4%)	44 (24%)	64 (35%)	37 (20.2%)	13 (7.1%)	6 (3.3%)
Dimension 3: Visual/ Verbal	**Strong Visual**	**Moderate Visual**	**Mild Visual**	**Mild Verbal**	**Moderate Verbal**	**Strong Verbal**
	37 (20.2%)	55 (30.1%)	47 (25.7%)	30 (16.4%)	11 (6%)	3 (1.6%)
Dimension 4: Sequential/ Global	**Strong Sequential**	**Moderate Sequential**	**Mild Sequential**	**Mild Global**	**Moderate Global**	**Strong Global**
	6 (3.3%)	17 (9.3%)	52 (28.4%)	59 (32.2%)	41 (22.4%)	8 (4.4%)

3. Experiment and Results

3.1 The purpose of the experiment

The experiment in this paper has been conducted to investigate the following research questions:
(1) Can students choose the LOs that mostly match their learning style while given LOs presented in a variety of types by CLLSS?
(2) What are the factors that affect the choice of students while given LOs presented in a variety of types while using CLLSS?
(3) While using CLLSS, are there any learning performance (including learning achievements, effectiveness, perception, cognitive load and so on) differences between students who are provided with all types of the LOs and choose LOs by their preferences and the students who are only provided with the LOs matching their learning style?

Moreover, the learning achievement of the two groups of students, who learned respectively with the two modes of CLLSS mentioned above, will be compared with a control group, who study a given textbook at the same time.

Obviously, it is very difficult to accommodate the full variety of learning styles in LOs of any chosen course. The experiment in this paper only focuses on the Visual/Verbal dimension of learning style since the LOs in language teaching have obvious contrast in this dimension.

From the experimental results, we aim to show the effectiveness of the learning support function of CLLSS and also search a better solution to the matching strategy of CLLSS.

3.2 Open mode and Learning Style Matching Mode of CLLSS

To find out the answers of the questions mentioned above, two CLLSS modes with two different strategies for LO suggestion are discussed in this paper: Open Mode and Learning Style Matching Mode. Figure 1 shows the LOs list of the grammar point "~tekudasai" in Open mode which provides both the visual and verbal LOs to the learner. Different from Open Mode, Learning Style Matching Mode only provides the visual LOs to visual learners and the verbal LOs to verbal learners.

The Learning Objects of [～てください]					
Exposure With Explanation					
Style		File Name		Average Rate	
Verbal explanation		tekudasaiEW.pdf		0.0	open
Practice					
Style	Type	File Name	Reference File	Average Rate	
Visual	Singing	tekudasaiPC.mp4	tekudasaiPCd.pdf	0.0	open
Visual	Pictures	tekudasaiPT.pdf	tekudasaiPTd.pdf	0.0	open
Verbal	Transformation	tekudasaiPZ.pdf	tekudasaiPZd.pdf	0.0	open
Verbal	Choice question	tekudasaiPX.pdf	tekudasaiPXd.pdf	0.0	open
Verbal	Words-order	tekudasaiPP.pdf	tekudasaiPPd.pdf	0.0	open

Figure 1. The list of LOs of the grammar points "~tekudasai" in Open mode.

3.3 Participants

Among the 183 students who participated in the ILS questionnaire, 90 of them participated in the experiment in this paper. In this experiment, participants used the Chinese version of the CLLSS system presented by Wang et al (2013).

These 90 first grade students from 3 different classes were taught by the 3 different instructors who had taught Japanese grammar course for more than seven years. Before the experiment, all the students already studied Japanese for six month. Although these 3 classes are using different reference books for the Japanese grammar course, the sequence of concepts in the past six month are mostly the same as the beginning of the course. And the teaching styles of these 3 instructors were all verbal style. The students hardly received any visual explanation or practice in previous classroom teaching.

The learning styles of participants in each class are shown in Table 3("before grouping" row).

Table 3: The participant profiles from the learning style perceptive.

		The number (and percentage)of every scale						Total
Visual/ Verbal dimension		**Strong Visual**	**Moderate Visual**	**Mild Visual**	**Mild Verbal**	**Moderate Verbal**	**Strong Verbal**	
before grouping	**Class 1**	3	6	11	4	0	1	25
	Class 2	4	7	4	4	1	0	20
	Class 3	10	14	7	9	4	1	45
	Sum	17 (18.9%)	27 (30%)	22 (24.4%)	17 (18.9%)	5 (5.5%)	2 (2.2%)	90
after grouping	**Experimental group A**	5	10	7	6	1	1	30
	Experimental group B	6	9	7	5	2	1	30
	Control group	6	8	8	6	2	0	30

Students from each class were assigned to be the experimental group A, B and the control group based not only on their learning style type in visual/verbal dimension but also on their learning achievement in last semester's final exam, so as to minimize the group composition differences. The learning styles of participants in each group are also shown in Table 3("after grouping" row).

3.4 Measurement techniques and Experimental Procedures

The Measurement techniques in this experiment included the learning achievement tests, and the questionnaires for measuring the students' learning perception, habits, and preferences and so on.

The test sheets were developed by two experienced teachers. The pre-test aimed to evaluate the students' knowledge about the learning target of 5 grammar points (GPs). The pre-test contained 10 transformation items with a perfect score of 10. The post-test contained 5 fill-in-blank items and 5 transformation items presented in verbal form, and 5 fill-in-blank items and 5 transformation items presented in visual form. Those 20 items are designed for assessing the students' knowledge of target contents in both verbal and visual aspects after the learning activity. The perfect score of the post-test was 100(50 for verbal aspect and 50 for visual aspect). (Since the participants hardly received any visual explanation or practice before the experiment, the visual form items are no considered in the pre-test. Also, before the experiment most of the participants have not learned these 5 GPs yet, so the scores of fill-in-blank items were too difficult and no suitable to be used to represent the students' knowledge about these 5 GPs.)

Figure 2 shows the procedures of the experiment. At the beginning of the experiment, all of them took the pre-test and learning attitude and motivation questionnaire (Questionnaire-1).

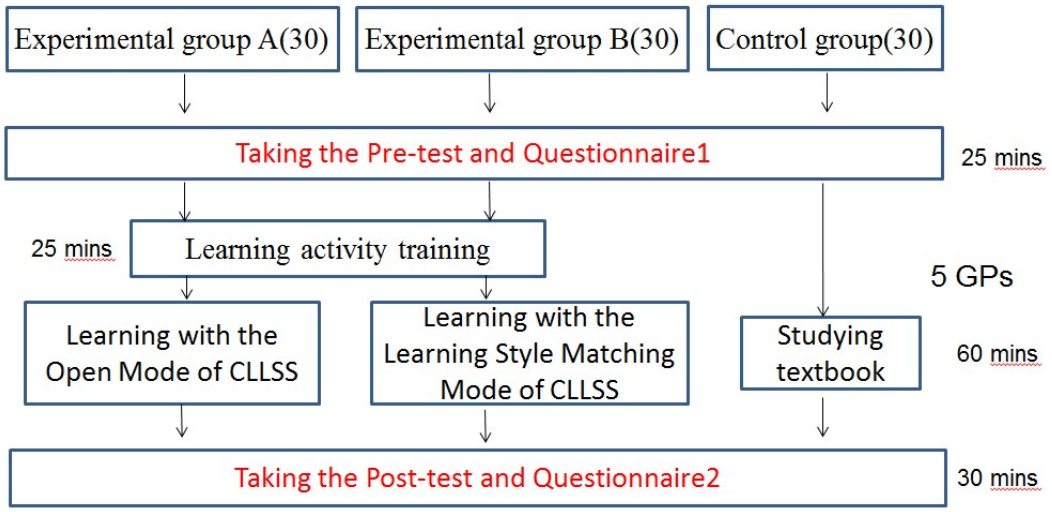

Figure 2. The experimentatl procedures.

Then, five GPs("~tekudasai", "~naru", "~to", "~nara" and "~temorau"), which mainly involved in Imperative Expressions, the Expressions of Change, Conditional Expressions, and Giving and Receiving Expressions, are chosen as target learning contents. The learning activity of experimental groups was performed in the computer-assisted language learning lab. After a 25 minutes training, the experimental group A with thirty students used the Open Mode of web-based CLLSS while the experimental group B with thirty students used the Learning Style Matching Mode of CLLSS for studying the target contents. Meanwhile, the control group in another classroom with thirty students studied with the given textbook. For all these three groups, the time of the learning activity towards the target contents was 60 minutes.

After the learning activity, all the students took the post-test and another questionnaire (Questionnaire-2) which involved learning attitude, motivation, habit and preference, technology acceptance measures, and cognitive load (the last two aspects just for experimental groups). Both two questionnaires written in Chinese are designed based on the measure tools respectively designed by Hwang and Chang (2011), Pintrich and DeGroot (1990), Chu et al. (2010) and Sweller et al. (1998) with some modifications.

3.5 The *Analysis of Learning perception*

The feedback about the learning activity and the system evaluation from the experimental groups, are shown in Table 4.

For the experimental group A, B, the average ratings of "Effort for understanding the target 5 GPs" (the maximum is 7) are 3.45 and 3.5 respectively. The average ratings of "Effort for understanding the purpose and the explanation of learning activity" (the maximum is 7) are 3.06 and 2.86 for the experimental group A and B respectively; this means most students in the experimental groups can easily understand the learning purpose of this activity.

In terms of technology acceptance measures of the experimental groups, the average rating of "It is easy to use this Mode of CLLSS" (1-3: strongly to slightly disagree, 4-6: slightly to strongly agree) received the average rating is 5.13 for group A and 4.94 for group B respectively; this means most students in the experimental groups felt that the CLLSS was easy to operate and get familiar with. The average rating of the item "This Mode of CLLSS is useful in learning knowledge" (1-3: strongly to slightly disagree, 4-6: slightly to strongly agree) is 4.94 for group A and 4.72 for group B respectively, implying that most students in the experimental group identified the usefulness of the CLLSS in improving their learning performances.

In terms of cognitive load, the average rating of the degree of distraction and pressure while using the CLLSS are both lower than 2.5 for both experimental group A and B, implying that using the CLLSS the students can concentrate on learning with low pressure.

Table 4: The MANOVA results of items about learning perception in Questionnaire-2.

				Technology Acceptance		Cognitive Load	
		Effort for the 5 GPs (1-7)	Effort for understanding the purpose (1-7)	Easiness of Mode (1-3:no 4-6:yes)	Usefulness of Mode (1-3:no 4-6:yes)	Distraction (1-7)	Pressure (1-7)
Group A	Mean	3.45	3.06	5.13	4.94	2.45	1.87
	S.D.	1.23	1.34	0.62	0.73	1.5	1.29
Group B	Mean	3.5	2.86	4.94	4.72	1.77	1.90
	S.D.	1.02	1.10	0.46	0.99	1.28	0.92
MANOVA(Wilks' Lambda)	Sig.	0.038* (P<0.05)					
Box's M Test		0.323* (P<0.05)					
One way ANOVA		0.918	0.675	0.150	0.340	0.041* (P<0.05)	0.857

The multivariate test result (Wilks' Lambda, $p<0.05$) indicates that there was a significant difference between the experiment group A and B in the ratings of the 6 items shown in Table 4.

Furthermore, the results of individual univariate analyses indicate that there was a significant difference in the rating of "Distraction" item between groups A and B; this suggests that the students who learned with Open Mode were easier to lose their attention than the students who learned with Learning Style Matching Mode while both using CLLSS. For the other five rating items in Table 4, the results show that there was no significantly different between the experimental groups A and B.

The Questionnaire-2 paper for experimental group A (who learned with the Open mode of CLLSS) had four items more than the one for experimental group B. The results of the addition items are shown in Table 5.

Table 5: The results of the addtional items in Questionnaire-2 of experimental group A.

Item	Question	Visual	verbal	total
1	Which type of LOs is more effective for you?	11(36.7%)	19(63.3%)	30
2	Which type of LOs you feel more comfortable with?	25(83.3%)	5(16.7%)	
3	Did you Struggle to make choice and sometimes get confused?	**YES**	**No**	
		18(60%)	12(40%)	

4	Did you preference change during the learning activity?	25(83.3%)	5(16.7%)	

According to Table 3, in experiment group A there are 15 students (including strong and moderate visual learner, totally 50%) which are stable visual learners and only 2 students (1 moderate verbal learner and 1 strong verbal learner, totally 6.7%) which are stable verbal learners. The rest 43.7% of student in this group with mild preferences would be expected to change their preference readily. And the result in item 2 of Table5 shows that 83.3% (falling into the range between 50% and 93.7%) of student in experiment group A were more comfortable with visual LOs; this coincides with the data in Table 3.

However, according to item 1 of Table 5, only 36.7% of students thought that the visual LOs were more effective for their study. Moreover, 53.3% (16 students) of students in experiment group A chose different answer in items 1 and 2; this means that more than half students using Open Mode thought the type of LOs, which they preferred more and felt more comfortable with, was not the type of LOs which is more effective for learning.

This situation may be caused by the students' learning habits. Since nowadays in China a majority of LOs of most curriculums especially Japanese Language course are presented in verbal form, the students already use to verbal LOs no matter what learning style they belong to. Moreover the final exams of those curriculums are mostly in verbal form; this also encourage the students emphasize the skill at verbal tasks more than visual tasks. This result implies that if the learning support system only provided learners in group A with the LOs matching their learning style (just as in Learning Style Matching Mode), about half of the students would believe that these LOs was ineffective for learning.

Furthermore, item 3 of Table 5 indicates 60% of student in experiment group struggled to choose LOs between visual and verbal type and even got confused sometimes. It is also found that the percentages of the students whose preference change with grammar points(shown in Item 4 of Table 5) are 83.3% (66.7% checked more teaching method if the grammar points is more difficult while 43.3% checked fix teaching method based on the type of grammar point).

4. Conclusion and Further work

From perspective of learning style, this study conducted a series of experiment for evaluating the different modes of a customizable language leaning support system called CLLSS (also designed by authors).

In the experiment in this paper, the Visual/Verbal dimension of learning style is considered from learning style perspective. Therefore, visual and verbal teaching methods, considered the two classifications in teaching methodology, enrich this teaching method ontology, which is one of the main ontology engines for CLLSS.

Furthermore, two modes were provided by CLLSS in this experiment: Open mode, which provides the learners with both the visual and verbal types of LOs, and Learning Style Matching Mode, which only provides visual learners with the visual LOs to and verbal learners with the verbal LOs.

In the preparatory phase, a survey using ILS questionnaire participated by 183 undergraduate students in the Japanese major, was conducted for collecting learning style distribution data. Among them, 90 students attended in the experiment in this paper and were assigned to be the experimental group A studying with Open mode of CLLSS, the experimental group B studying with Learning Style Matching Mode of CLLSS, and the control group studying with the given textbook.

From the analysis of learning perception of experiment groups, the points listed below, suggested by the results, are worthy of consideration: (1) the students who learned with Open Mode are easier to lose their attention than the students who learned with Learning Style Matching Mode while both using CLLSS; (2) for the student using Open Mode, 83.3% of them are more comfortable with visual LOs, but only 36.7% of them thought that the visual LOs are more effective for their study; (3) more than half students using Open Mode thought the type of LOs, which they preferred more and felt more comfortable with, was not the type of LOs which is more effective for learning (4) 60% of students using Open Mode suffered from the decision between visual and verbal LOs.

In further work, the learning achievement differences among the two experimental group and control group will be analyzed based on the pre-test and post-test scores. Furthermore, the learning attitude, motivation, technology acceptance measures aspects will also be discussed.

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