

Evaluation Method of Web-based Learning System

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Abstract

In this paper, we propose a method that helps us extract important evaluation parameters both for measuring the effectiveness of the Web-based learning system and for characterizing the difference between classroom learning and Web-based learning. We used AHP (Analytic Hierarchy Process) to extract the parameters. We applied our method to real class room and succeeded in capturing several important parameters.

1. Introduction

Web-based distance learning system supports distributed and asynchronous learning. *Web-based learning* approach become more popular, and many Web-based learning systems have been developed[2]. It is necessary to give the above community a method of evaluating the Web-based learning systems to make it easier to improve them.

We have already proposed a preliminary version of an evaluation method using analytic hierarchy process (AHP) [1]. In this paper, we propose a method for extracting important parameters that will influence the effectiveness of learning and will characterize difference between classroom learning and WEB-based learning. We applied our method to real class room and succeeded in capturing several important parameters.

2. Evaluation Method by AHP

2.1 What is an AHP?

In decision-making, there is usually a "question" and some "alternatives" for the final decision. There are several "criteria" for choosing a final decision among some "alternatives". AHP helps us choose one of several alternatives effectively based on some criteria[3]. In the AHP hierarchical structure shown in Figure 1, we call it an AHP template, the question is "In which styles of learning do you think you can learn effectively".

Alternative#1 is Web-based learning system.
 Alternative#2 is decided by the AHP Diagram Designer.
 There are several "criteria" and a decision by the following procedure.

1. The weight of each criterion is calculated by giving a weight to every pairs of criteria.
2. Total score (100 points) is divided among criteria according to the weight of each criterion (score of

each criterion).

3. At each criterion, the weight of each alternative is calculated by giving a weight to every pairs of alternative. The score of each criterion is divided among alternatives according to the weight.
4. The score of each alternative is calculated by adding the scores of every criterion.

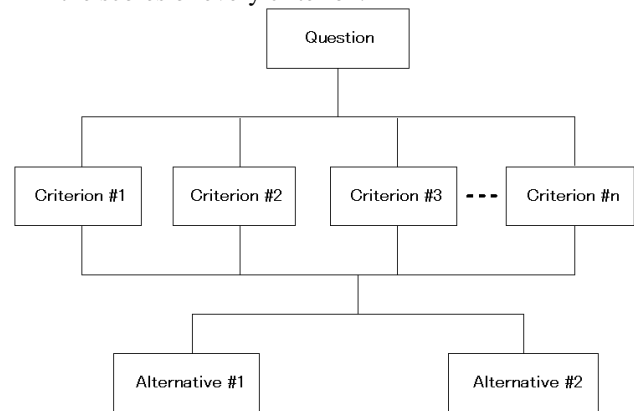


Figure 1 AHP Hierarchical Diagram Template

2.2 Evaluation Method

We show our method in Fig.2. The method is represented by a UML activity diagram. In Fig.2, there are four "swim lane"s: Subject; Experimenter; AHP diagram Designer; and Analyst. A circled box shows an activity and a solid arrow shows a flow of control. A rectangular box shows an object passed through from some activity to the other represented by a dashed arrow. In Fig.2,

1. "Subjects" take a lecture by Web-based learning system and answer a question given by a "Experimenter".
2. "Experimenter" performs an experiment to collect data.
3. "AHP Diagram Designer"
 - (1) decides another learning style , e.g. Vod based or Classroom, compared to Web-based learning
 - (2) decides the criteria and completes the AHP diagram(see Fig.4)
 - (3) calculates weight and score for each criterion
 - (4) finally decides the score for each alternative

4. "Analyst"

- (1) calculates an average of scores for each criterion.
This score implies that criterion is useful for evaluating the learning system.
- (2) classifies criteria into several categories by an average of scores, e.g. high and low
- (3) compares the average of scores of Web-based learning system with the average of scores of

another learning style for each criterion. Does F-test to know the difference is significant. If it is significant, the criterion is a useful parameters to characterize the difference between the Web-based learning and another learning style.

- (4) Makes the characteristic table(see Table 3)
- (5) Improves the teaching material based on the results

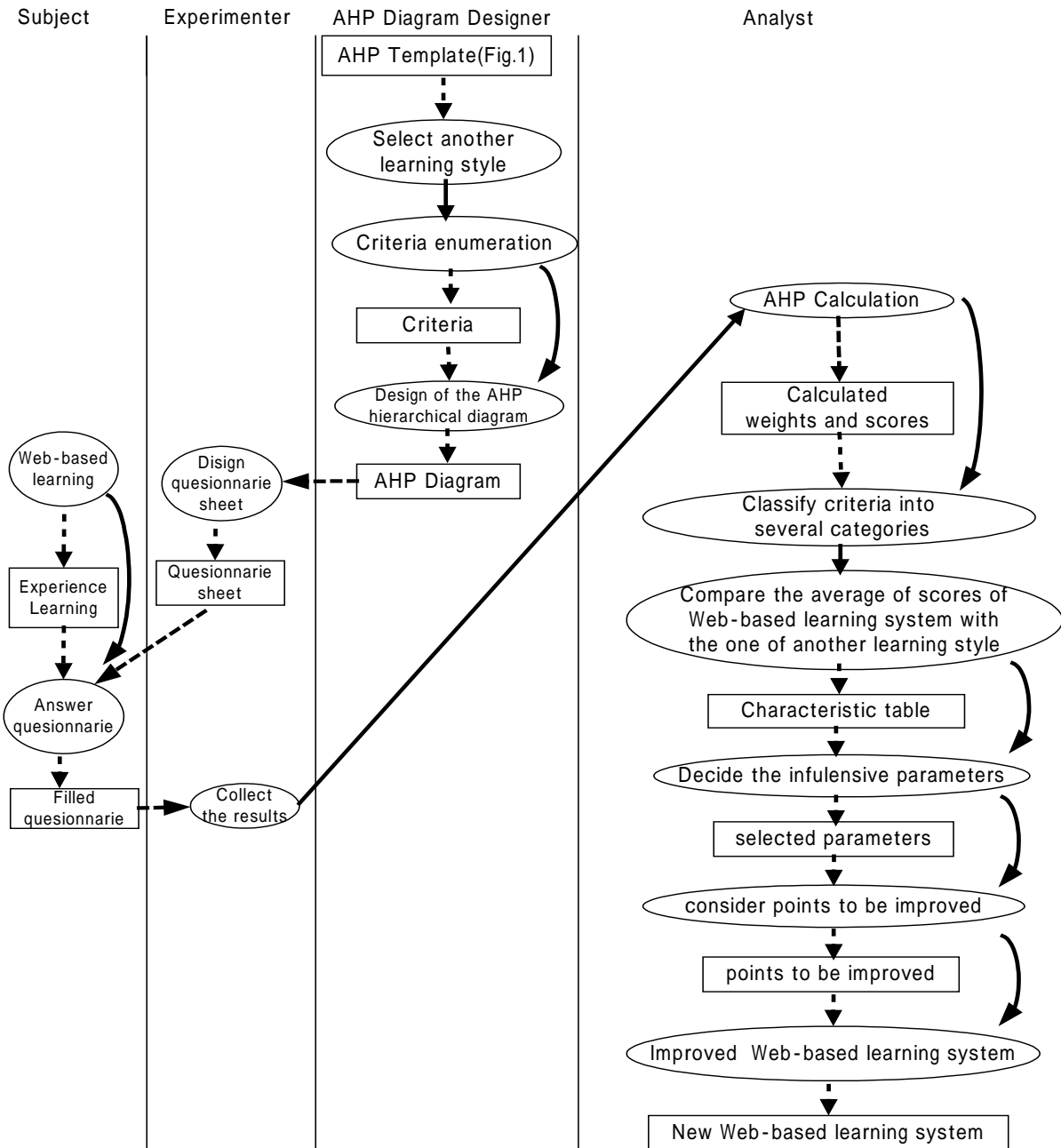


Figure 2 Evaluation Method

3. Design of an AHP Hierarchical Diagram

We designed the AHP hierarchical diagram to compare Web-based learning with classroom learning.

3.1 Web-based Learning System

We developed the Web-based Learning system in the JAIST Virtual University Project. This system is designed for learning “Artificial Intelligence” and given by Professor Tojo in JAIST. Figure 2 shows the snapshot of the system .



Figure 2 Our Web-based Learning System

This course is composed of 15 lectures. One lecture takes about 50 minutes. Note that one usual classroom lecture takes about 90 minutes. Our system is composed of the video image of teacher, presentation material viewer, text viewer, movie slider function toolboxes, knowledge units index, FAQ and bulletin board links. In the video viewer of teacher, the video image of the RealVideo format taken a picture by focusing on the teacher is displayed. In sub materials viewer, the presentation materials are displayed synchronizing with the video image. They can be also displayed the marking to explanation part by using Macromedia Flash for intelligibility. In the text viewer, the content that the teacher spoke is displayed as it is. So learners can confirm the part they missed hearing, and take a note. They can also study the meaning of the term of texts because there is a link to the glossary. The left area is INDEX frame. Each knowledge unit is linked here. In addition, learner can take communications as interactive function by using FAQ and the bulletin board that can be used by not only the teacher but also those who learn. This system requires a personal computer with Windows OS, use Internet Explorer 5.later or Netscape Communicator 4.later, and it

is necessary to install Realplayer G2 and Macromedia Flash as a plug-in.

3.2 AHP Hierarchical Diagram

The AHP hierarchical structure designed is shown in Figure 3. The “alternatives” is classroom learning. The criteria of Level 2 are refined into the criteria of Level 3 to compare the effectiveness of WEB-based learning with that of classroom learning, from the viewpoint of which factors are needed to learn effectively.

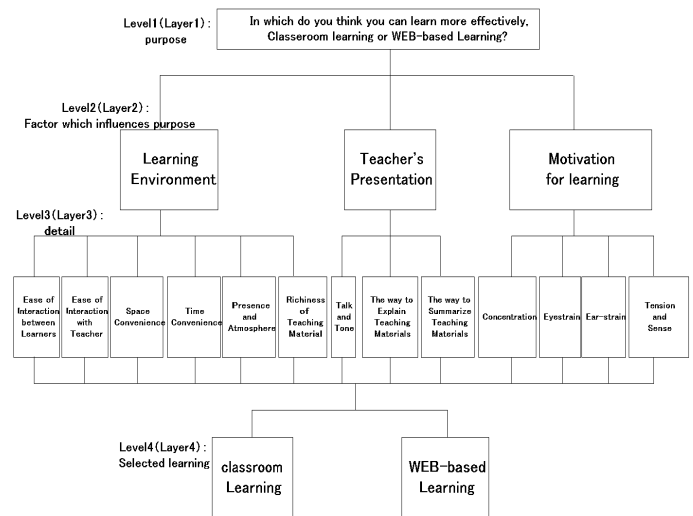


Figure 3 Design of AHP Hierarchical Diagram

A. Learning Environment: Learners have different styles of learning, They might learn in a manner that suits their styles. This criterion is divided into the following six criteria.

1. **Ease of Interaction between Learners:** Ease and smoothness of communication among learners.
2. **Ease of Interaction with Teacher:** Ease and smoothness of communication between learners and a teacher.
3. **Space Convenience:** Learners may want to take lecture at the place where they are.
4. **Time Convenience:** Learners may want to take lecture whenever they like.
5. **Presence and Atmosphere:** A student may feel the presence of the teacher in a classroom . When students learn the most important things, there may be in a tense atmosphere in the classroom.
6. **Richness of Teaching Material:** Usefulness of teaching materials.

B. Teacher's Presentation: Presentation method with which the teacher provides knowledge and concepts. We divide it into the following three criteria.

7. **Talk and Tone:** Comfortableness of the teacher's talk and tone.

8. The way to Explain Teaching Materials: Ease of understanding the way to explain teaching materials.

9.The way to Summarize Teaching Materials: Ease of understanding summarization of teaching materials.

C. Motivation for Learning: This criterion is a measure for evaluating learner’s motivation and continuity of learning. We divide it into the following four criteria.

10. Concentration: Concentration without considering surroundings.

11. Eyestrain: Degree of eye-strain

12. Ear-strain: Degree of ear-strain.

13. Tension and Sense: Commitment to learning.

4. Experiment Environment

We set up several experiments where students study themselves using Web-based system instead of teacher’s talk. The experiments were performed as a part of real classroom lecture of “Artificial Intelligence” in JAIST. At the experiments, we performed the following lecture (five times).

1. 4th Logical Inference #1
2. 5th Logical Inference #2
3. 9th Prolog programming
4. 11th Knowledge Representation and Expert System
5. 12th Planning

Students who attended the lectures were able to use our Web-based learning system by personal computers connected to local area network. We made two kinds of questionnaire sheets for evaluation by AHP. One is a sheet to give a weight to every pairs of criteria. Another is a sheet to give a weight to Web-based learning and classroom learning to each criterion. We collected sheets answered by students who attended empirical lectures.

5. Results of Experiment

In this section, the results of evaluation are described.

5.1 The 1st Evaluation by AHP

After the lecture of “5th Logical Inference #2”, we got questionnaire sheets answered by 68 students. We understood from the answer of the questionnaire of the sheets that the most of learners used Web-based learning system first time. We excluded the four students because the value of his/her AHP adjustment (C.I.) exceeded the permitted value. The C.I. is a criterion for measuring consistency when subjects evaluate a weight.

We calculated the average weights of every criterion. Figure 4 shows a radar diagram mapping the weights. The average weight of “10.Concentration” was the highest. Interaction between learners was the lowest.

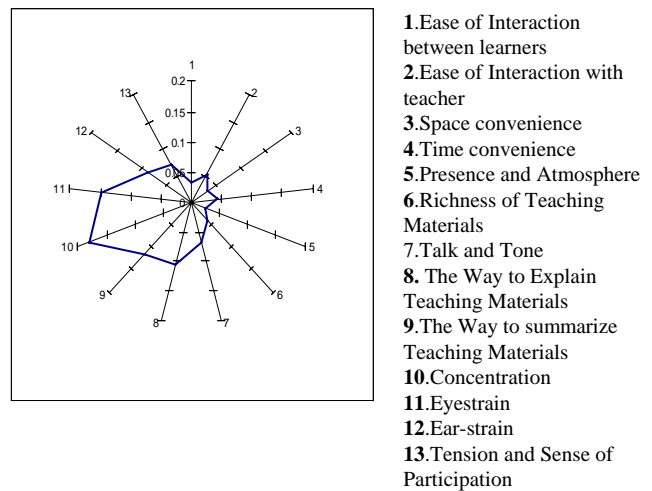


Figure 4 Weight Radar Diagram (1st Evaluation)

100 points (total score) were divided among 13 criteria according to the weight of each criterion. And each score was divided among classroom learning and Web-based learning according to the weights of each learning. Table 2 shows classroom learning scores and Web-based learning scores of every criterion.

Criterion	Classroom		WEB	Results of F-test	Score
10.Concentration	10.747	>	6.170	$f = 20.27 > F(1,127,0.05)$	17.5
11.Eyestrain	8.761	>	6.945	$f = 6.53 > F(1,127,0.05)$	14.7
9.The Way to Summarize Teaching Materials	4.602		6.743	$f = 2.03 < F(1,127,0.05)$	11.3
8.The Way to Explain Teaching Materials	3.452		6.106	$f = 4.34 < F(1,127,0.05)$	10.6
12.Ear-strain	5.198	>	3.677	$f = 6.36 > F(1,127,0.05)$	8.8
13.Tension and Sense	5.165	>	1.857	$f = 24.76 > F(1,127,0.05)$	7.1
7.Talk and Tone	3.619		3.405	$f = 0.05 < F(1,127,0.05)$	7.0
2.Ease of Interaction with Teacher	3.409		1.874	$f = 4.94 < F(1,127,0.05)$	5.3
4.Time Convenience	0.311	<	4.360	$f = 17.87 > F(1,127,0.05)$	4.3
6.Richness of Teaching Materials	1.561		2.504	$f = 4.88 < F(1,127,0.05)$	4.0
1.Ease of Interaction between Learners	1.899		1.539	$f = 2.47 < F(1,127,0.05)$	3.4
3.Space convenience	0.891	<	2.610	$f = 11.99 > F(1,127,0.05)$	3.3

5.Presence and Atmosphere	2.106	>	0.551	$f = 10.01 > F(1,127,0.05)$	2.7
Total	51.721	>	48.341	$f = 8.43 > F(1,127,0.05)$	100

Table 1 Classroom Learning Scores and Web-based Learning Scores of each Criterion (1st Evaluation)

	Statistical Significant Difference	No Statistical Significant Difference
Score is High	Criteria in this area (Area 1) will be regarded as important parameters that influence the effectiveness of learning and characterize difference between classroom learning and WEB-based learning.	Criteria in this area (Area 3) will be regarded as important parameters that influence the effectiveness of learning.
Score is Low	Criteria in this area (Area 2) will be regard as important parameters characterize difference between classroom learning and WEB-based learning.	Criteria in this area (Area 4) will be regarded as unimportant parameters.

Table 2 Four Categories by Score Level and Existence of Difference

The third row shows the order of precedence by the results of F-test (a statistical significant level is 5%) in a decentralized analysis. Note that the blank space shows no significant difference. We think that statistical significant difference between scores of classroom learning and Web-based learning will characterize styles of learning. We also think that the levels of scores will show the effectiveness of learning. Table 2 shows four categories by matrix of score level and existence of difference.

	Statistical Significant difference $f > F = 5.1524$	No Statistical Significant difference $f < F = 5.1524$
Score is High (≥ 7.69 points)	10,11,12	8,9
Score is Low (< 7.69 points)	3,4,5,13	1,2,6,7

Table 3 Classifications of Criteria (1st Evaluation)

Table 3 shows 13 criteria classified into four categories. We regarded the average score of criteria as the threshold of the high and low. In Table 3, the threshold value is 7.69.

“10.Concentration”, “11.Eyestrain” and “12.Ear-strain” are classified into Area 1. Studying themselves in Web-based learning may cause the significant difference. Motivation for learning will be an important parameter that influences the effectiveness of learning and characterizes classroom learning. “3.Space Convenience”, “4.Time Convenience”, “5.Presence and Atmosphere” and “13.Tension and Sense” are in Area 2. We think that the convenience will show the characteristic of Web-based learning. We also think that the presence and atmosphere will show the characteristics of classroom learning. “8.The Way to Explain Teaching Materials”, and “9.The Way to Summarize Teaching Materials” are in Area 3.

We think that teacher’s presentation would be an important parameter the effectiveness of learning. “1.Ease of Interaction between learners”, “2.Ease of Interaction between learners”, “6. Richness of Teaching Materials” and “7.Talk and Tone” are in Area 4. We think that their criteria will be not an important parameter.

5.2 The 2nd Evaluation by AHP

The weight of the “Learner’s Motivation” was much higher than the other criteria at the 1st evaluation by AHP. To examine influence caused by the other criteria in detail, we changed the AHP hierarchical diagram as shown in Figure 5. After the lecture of “12th Planning”, we got questionnaire sheets answered by 64 students. We excluded the five students because the value of his/her AHP adjustment (C.I.) exceeded the permitted value.

We calculated the average weights of every criterion. Figure 6 shows a radar diagram mapping the weights. The weight of “9.The way to Summarize Learning Contents” was the highest. The weight of “PresenceAtmosphere”

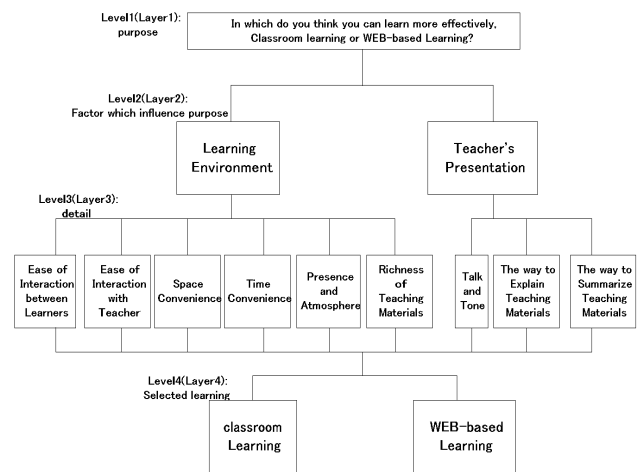


Figure 5 Improved AHP Hierarchical Diagram

was the lowest. 100 points (total score) were divided among 9 criteria according to the weight of each criterion.

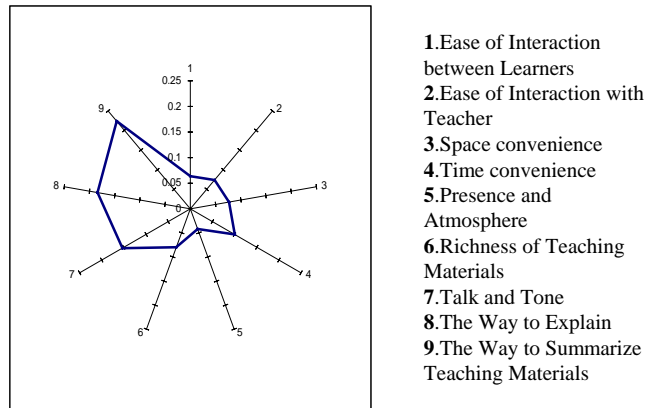


Figure 6 Weight Radar Diagram (2nd Evaluation)

And each score was divided among classroom learning and Web-based learning according to the weights of each learning. Table 4 shows the scores. In this table, the scores of classroom learning and Web-based learning of every criterion are shown. The order of precedence is shown according to the results of F-test (a statistical significant level is 5%) in a decentralized analysis. Table 5 shows 9 criteria classified into four categories. We regarded the average score of criteria as the threshold of the high and low the same as in Table 3. In Table 5, the threshold value is 11.1. There is no criterion in Area 1. “2.Ease of Interaction with Teacher”, “3.Space Convenience”, “4. Time Convenience and “5.Presence and

Atmosphere” are in Area 2. “7.Talk and Tone”, “8.The Way to Explain Teaching Materials” and “9.The Way to Summarize Teaching Materials” are in Area 3. “1.Ease of Interaction between learners “6.Richness of Teaching Materials are in Area 4.

We compared the results of Table 3 with ones of Table 5. The area of “7.Talk and Tone” was different. That is, in Table 5, the score of the criterion tended to be higher than the other scores. We think that talk and tone of a teacher will be an important parameter the effectiveness of learning. Difference between the scores of classroom learning and Web-based learning of “2.Ease of Interaction with Teacher” was statistical significant in Table 5. At the 1st evaluation, f-desperation-value and F-value (5%) of “2.Ease of Interaction with Teacher” was very close. We think that the ease of interaction with a teacher will show the characteristics of classroom learning. However, we will need to examine the parameters.

6. Conclusions

In this paper, we described the method using AHP to extract important parameters both for measuring the effectiveness of the Web-based learning system and for characterizing the difference between classroom learning and Web-based learning. We plan to improve our Web-based system based on the parameters. We also plan to examine usefulness of our method by performing another experiment after improving Web-based learning system using the extracted parameters

Criterion	Classroom	WEB	Results of F-test	Score
9.The Way to Summarize Teaching Materials	10.765	11.689	$f = 2.13 < F(1,117,0.05)$	22.4
8.The Way to Explain Teaching Materials	8.972	9.584	$f = 2.10 < F(1,117,0.05)$	18.6
7.Talk and Tone	8.047	7.276	$f = 3.25 < F(1,117,0.05)$	15.3
4.Time convenience	2.509	< 7.490	$f = 9.41 > F(1,117,0.05)$	10.0
6.Richness of Teaching Materials	3.696	4.383	$f = 2.85 < F(1,117,0.05)$	8.0
3.Space convenience	2.427	< 5.283	$f = 24.13 > F(1,117,0.05)$	7.7
2.Ease of Interaction with Teacher	4.601	> 2.808	$f = 5.99 > F(1,117,0.05)$	7.4
1.Ease of Interaction between Learners	3.343	3.105	$f = 0.28 < F(1,117,0.05)$	6.4
5.Presence and Atmosphere	2.939	> 1.291	$f = 6.03 > F(1,117,0.05)$	4.2
Total	47.299	< 52.909	$f = 8.42 > F(1,117,0.05)$	100

Table 4 Classroom Learning and Web-based Learning Scores of each Criterion (2nd Evaluation)

	Statistical Significant difference $f > F = 5.0239$	Not Statistical Significant difference $f < F = 5.0239$
Score is High (≥ 11.1 points)		7,8,9
Score is Low (< 11.1 points)	2,3,4,5	1,6

Table 5 Classifications of Criteria (2nd Evaluation)

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