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Evaluating an Adaptive Learning Materials based on Student's Learning Style and Ability

UtomoBudiyanto, Sri Hartati, Azhari S.N., DjemariMardapi

PhD Student, Department of Computer Science and Electronics, GadjahMada University, Yogyakarta, Indonesia
Full Professor, Department of Computer Science and Electronics, GadjahMada University, Yogyakarta, Indonesia
PhD, Department of Computer Science and Electronics, GadjahMada University, Yogyakarta, Indonesia
Full Professor, Department of Research and Evaluation in Education, Yogyakarta State University, Yogyakarta, Indonesia

ABSTRACT:The E-Learning system presented the same learning materials for each learner. This is often called one size fits all. Learners have different backgrounds that require different things also in learning. The learners' background is very diverse among the learning style and level of ability. This research is used learning style parameters and the level of ability of learners to present learning materials in accordance with these parameters. The learning style parameters are applied to determine the appropriate way of learning according to their style while the level of ability is determined the level of learning material presented. Felder Silverman Learning Styles Model (FSLSM) is the learning styles model used in this research. Computer Based Test (CBT) is applied to determine the level of ability of learners use a test using Rasch Model one of the types of Item Response Theory (IRT).The present learning materials had used the two parameters with the recommendation rules technique. Dominant learning style preference is Active Sensing Visual Sequential of 46.67% based on the results of the testing of the model of this e-learning system. Level of student's learning materials understanding of 93.32% and the level of suitability of learning materials presented amounted to 86.66%.

KEYWORDS: Adaptive E-Learning, Computer Based Test, Felder Silverman Learning Styles Model, Rasch Model, Recommendation Rules.

I.INTRODUCTION

E-learning is basically a computer-based learning tool or a system allowing us to be able to learn whenever and wherever. This media is mostly delivered over the internet network currently, although it was provided using a mixed method of the computer as CD-ROM. The rapid technological developments made geographical distance differences a solution with existing technology learners will be experiencing they are in a classroom (Epignosis LLC, 2014).

The current E-Learning system generally presents the same material for each learner regardless of the learner characteristics (Huang et al., 2010). Learners will have problems in learning if learners have different ways of learning and their learning styles do not match the way in the educational environment (Felder and Silverman, 2002). Inferential statistical results are shown that different learning styles have a significant effect on the flow of experience, different learning styles have a significant effect on overall learning effectiveness, and the flow of student experience is correlated with the effectiveness of (Rong and Min, 2005).

The different learning style preferences have shown significantly different behaviors in online learning. This becomes important in order to provide learning including features suitable different learning styles (Graf and Kinshuk, 2006). Knowing students' learning styles and presenting materials blend each student's learning styles has the potential to make learning easier for students and improve learning progress (Graf et al., 2008).The learning styles theories have been introduced by researchers such as Kolb (1984), Honey and Mumford (1986) and Felder and Silverman (FSLSM) (2002).

E-learning is not enough to meet the needs of learners that provides different learning for each learner based on learning style alone. The learner's ability is important and often overlooked moreover need in the personal learning

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mechanism (Chen et al., 2005, Baylari and Montazer, 2009). Both combinations will make e-learning meet the learners' needs.

Khairina et al. (2017) identify learners' learning styles used VARK (Visual, Audio, Read / Write, Kinesthetic) models and ontology to present learning strategies, while Suteja et al. (2015) identifies learning styles based on the Felder Silverman Learning Style model and uses an ontology to recommend learning materials. Learners will get learning materials in accordance with their learning styles. Surjono (2014) evaluated Moodle's adaptive e-learning system (software for learning management system) according to learners' learning styles. Learning styles used are VAK (Visual, Auditory, Kinesthetic). Implementation using a questionnaire to identify the learner's learning style trend. Scores of results from this questionnaire will be used by the system to present different learning materials for each learner.
The learners level of ability to the learning materials and learning styles are important factors. Knowing the learning style will be used to recommend the learning materials and strategies presented (Khairina et al., 2017, Suteja et al., 2015) while knowing the level of learners' abilities can be used to recommend materials and learning strategies according to their level of ability.

Therefore, the requirement E-learning system is able to provide learning materials in accordance with learning styles and the ability of learners.it will be determined appropriately in learning materials for each learner for knowing the learning style and the ability of the learner

This research proposes the model of E-Learning system according to the needs of learners. In this case, the needs of learners are the learning style as well as the level of ability. The learning style model used is FSLSM because it is best suited to computer-based learning (Carver et al., 1999) as well as using Item Response Theory with 1 Parameter or the so-called Rasch Model to determine the level of ability of the learners. From both parameters, the learners will get the learning materials in accordance with the learning style and level of ability. To determine the suitability of learning materials with learning style and level of ability used recommendations in the form of rules (recommendation rule).

II. LEARNING STYLES

The current E-Learning system generally presents the same material for each learner regardless of the learner characteristics (Huang et al., 2010). learners will have problems in learning if learners have different ways of learning and their learning styles do not match the way in the educational environment (Felder and Silverman, 2002). Inferential statistical results are shown that different learning styles have a significant effect on the flow of experience, different learning styles have a significant effect on overall learning effectiveness, and the flow of student experience is correlated with the effectiveness of.

Everyone has the style of learning and it will determine the learning process so different recommendations are needed for each learning style. Felder and Silverman Learning Style Model (FSLSM) (2002) describes learning styles in more detail by distinguishing between learners' preferences into four dimensions: 1) the active-reflective 2) sensing-intuitive 3) visual-verbaland 4)sequential-global.

To determine the learning style using FSLSM, a learning style questionnaire such as those found at https://www.engr.ncsu.edu/learningstyles/ilsweb.html consists of forty-four questions. The question is divided into four dimensions, so each dimension has eleven questions. with values ranging from +11 to -11 with addition / subtraction of +/- 2. Each question has a +1 value for answer a or -1 for answer b. Answer a refers to the first part of each dimension: active, sensing, visual or sequential whereas answer b will refer to the next part of each dimension: reflective, intuitive, verbal or global.

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III. LEARNER'S LEVEL OF ABILITY

The test uses the CBT (Computer Based Test) technique that presents the test by adjusting the ability level of the participants to utilize the item characteristics in IRT (Item Response Theory). The IRT parameters used are 1-PL or otherwise known as Rasch Model.

Item Response Theory (IRT) is a psychometric theory providing a basis for measuring the scale of test participants and questions based on the responses given to the problem in order to provide similarities between the statistical problems and the learner's estimation of ability.

Classical measurement theory is also known as classical test theory and the level of difficulty items dependent on the ability of respondents. The items are not difficult for high-ability respondents. However, items are difficult. In the item is not difficult for low-ability respondents. it appears the ability of respondents to be high. On the hard point, it appears the ability of the respondents to be low. The difficulty level of item depends on the ability of the respondent. The same item will feel heavy for those who are low-ability and light to those who are capable.

The ability of respondents is depended on item difficulty, those who work on difficult items will appear to be inferior while those who work on the item will appear highly capable. The classical measurement theory cannot be used for matching respondents' ability with the item difficulty specifically for the dependent. In classical theory, there is interdependence between the respondents' ability and the difficulty of the item. The recommendation method of mentioning the measurement results is matched with the name of the measuring instrument.

For example, 450 TOEFL, 630 SPMB (Sudaryono, 2013). Measuring results can be understood in relation to the measuring instrument used (TOEFL or SPMB). We recommend that the name of the measuring instrument be widely known by many people. On the test, modern measurement theory is known as modern test theory (modern test theory). In modern measurements, the item difficulty level is not directly related to the ability of the respondents.

In modern measurements, the item difficulty level is directly related to item characteristics. The item-intensive point of the modern measurement lies in: P (θ) = Pmin + 0.5 (Pmax - Pmin) = Pmin + 0.5 (1 - Pmin). The items difficulty level is given b notation. In modern measurements, the item difficulty level is directly related to item characteristics. The high and low (θ) abilities have the same difficulty point b. The respondent ability and the difficult item level is becoming independent. Modern measurements can be used to match the ability of respondents to item difficulty.

The item characteristics are determined by respondents' responses (both high and low ability) so they are known as response theory (Item Response Theory). This theory is also known by various names, such as Latent Trait Theory (LTT), Item Characteristic Curve (ICC), Item Characteristic Function (ICF). Fundamentally, the item character is the regression between the ability and the probability of answering correctly.

The item response theory is necessary to determine the model of relevant characteristics item, it can be one parameter (1P) is shown in equation (1), two parameters (2P) is shown in equation (2), three parameters (3P) is shown in equation (3), or other models.

$$1P: P(\theta) = f(b, \theta) \quad (1)$$

$$2P: P(\theta) = f(a, b, \theta) \quad (2)$$

$$3P: P(\theta) = f(a, b, c, \theta) \quad (3)$$

One, two and three are the number of item parameters. Parameter θ is person ability. The parameter b is difficulty. In 1P and 2P, b = θ when P (θ) = 0.5. At 3P b = θ when P (θ) = 0.5 (1 + c). Parameter a is a discrimination. The parameter c is the pseudo-guessing. Rasch Model is the response theory of item that use 1 parameter is the difficulty level of item.

Preparation and presentation of questions in evaluation have nine steps in preparing the standardized test results or achievements as follows (Mardapi, 2015): (a) Prepare the test specifications (b) Write the test (c) Check the test (d) Testing the test (e) Analyzing the test items (f) Fixing the test (g) Assembling the test (h) Implementing the test (i) Interpreting the test results.

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A. E-LEARNING MODEL

Budiyanto et al (2017) developed the model of e-learning system architecture showing in Fig 1, there are three main stages in this model are: learning style identification and identify learner's ability level off.

Model of e-learning system can be seen in figure 1; learners will be identified learning style using FSLSM method by filling questionnaire as many as 44 questions. Afterward, it will be known learning style of learners that is one of sixteen possible combinations of learning styles. That is to determine the level of ability by choosing material provided with Beginner, Intermediate or Advanced levels. Computer Based Test (CBT) stage is used to determine whether the learners can follow the learning at the chosen level if it fails the learner can choose the level below.

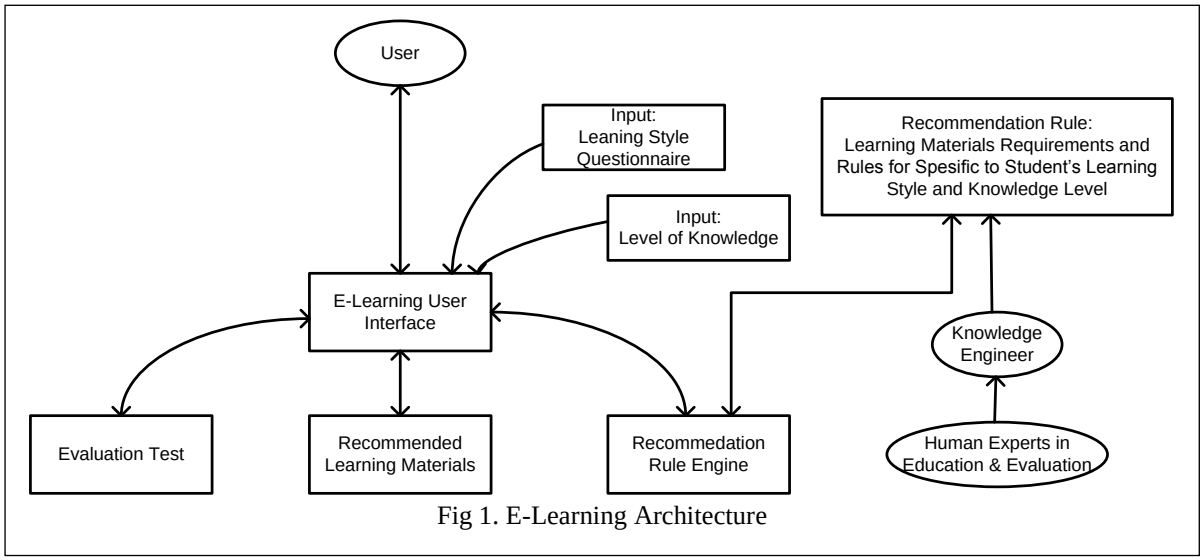

Fig 1. E-Learning Architecture

After obtaining the learning style and ability level, the learning process can be done by the teachers. Then a test will conduct whether the learning process runs well. If it passes, then it will go to the next level whereas if it fails, the model will show which part of the learning materials that have not been understood so that learners can repeat the learning process.

The process of e-learning system stages is divided based on activities undertaken by learners and teachers. Stages performed by the learner seen in Fig 2 that is: 1) login to enter the e-learning system 2) check whether learners already have dominant learning style preferences 3) learning style identification process 4) check whether the learners have a level of ability 4) select the level of ability (beginner, intermediate, advanced) 5) computer based test based on the level chosen in the previous step 6) online learning that is suited to the learning style and the level of ability of learners 7) rating on learning materials presented 8) evaluation of learning outcomes using CBT per learning material 9) if it fails, the learning style preferences will be re-identified 10) if it passes, the step-6 will be repeated until the learning material is completely followed by learners.

Stages performed by the teacher seen in Fig 3 that: 1) login to enter the e-learning system 2) unit management of lecture subject based on the curriculum 3) determining the level of each learning materials 4) preparation of bank questions for test purposes level and per learning material 5) preparation of recommendation rules according to the dominant preference of learning style with learning materials 7) management (input, change, delete) learning materials.

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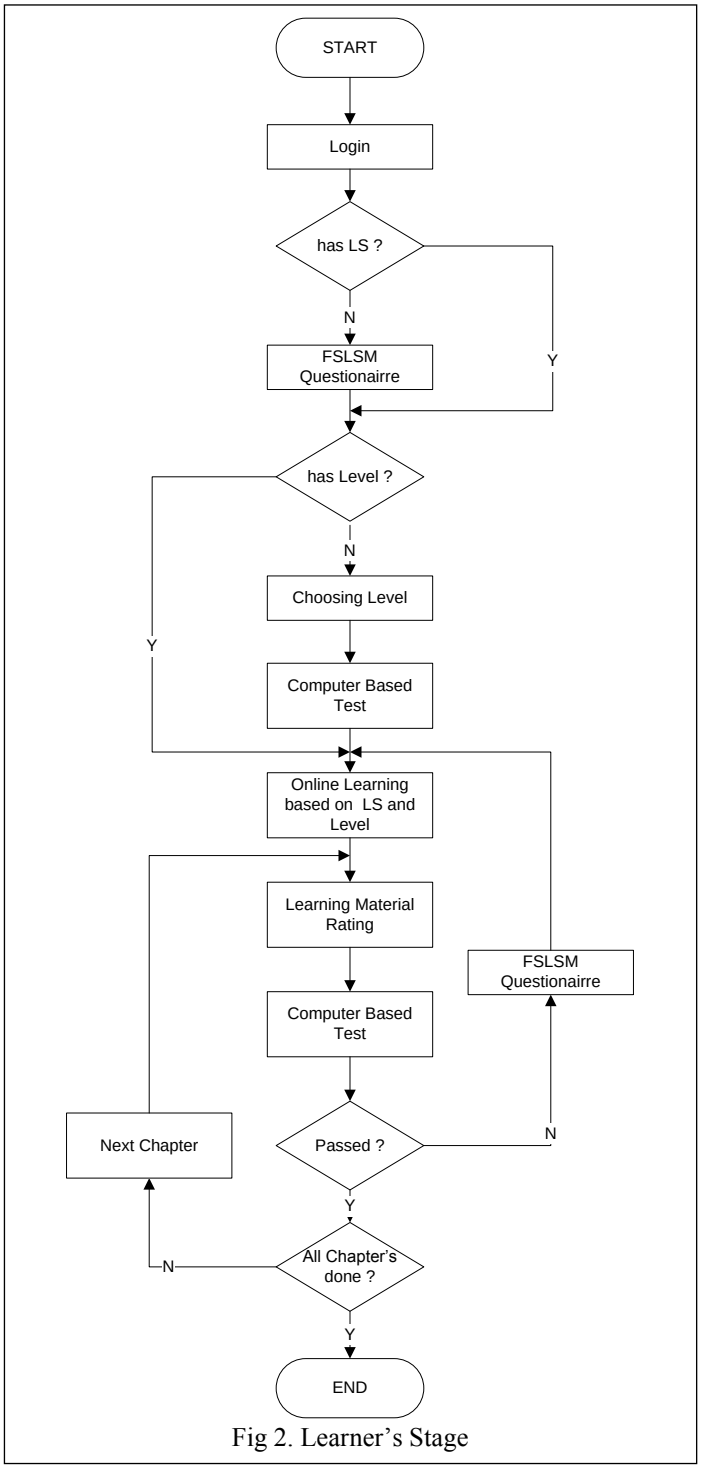

Fig 2. Learner's Stage

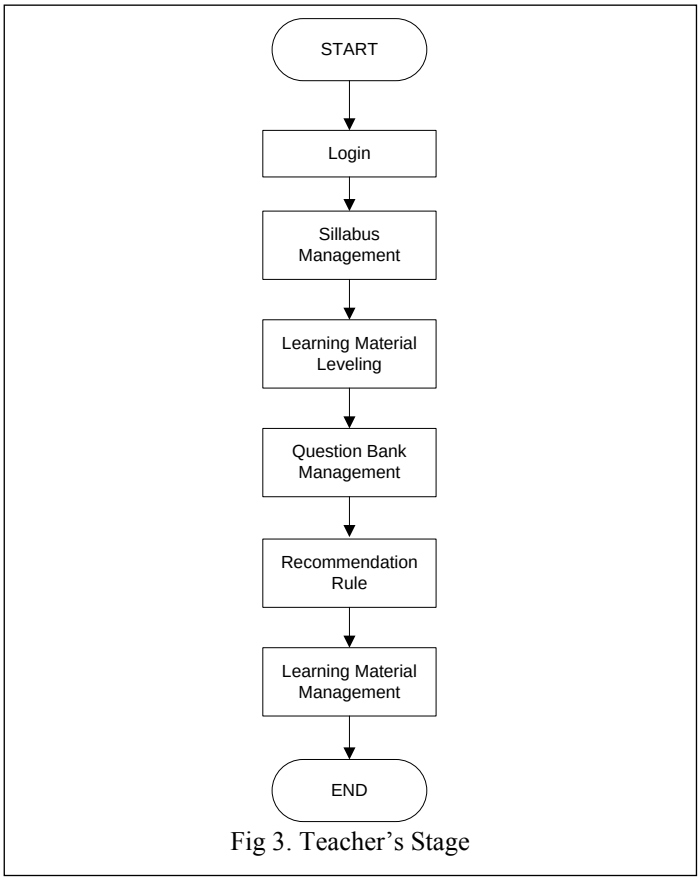

Fig 3. Teacher's Stage

IV. RESULTS AND DISCUSSION

The initial process of this system is the identification of learners' learning styles. This activity is done to get learners style preference. The steps taken are to fill in the questionnaire provided.
Questionnaires to be filled by learners use the Felder Silverman Learning Style model. This model divides the students' learning style preferences into four dimensions: processing dimension, the dimension of perception, input dimension

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and understanding dimension. Each dimension has eleven questions with two answer choices. So the total number of questions becomes forty-four.

Each dimension has two opposing preferences. The processing dimension has Active and reflective preferences, the perception dimension has sensing and intuitive preferences, the input dimension has visual and verbal preferences, the dimensions of understanding have sequential and global preferences. Each preference will determine the appropriate learning. The combinations generated from all dimensions are sixteen learning styles. Thus the questionnaire will get one of sixteen possible combinations.
Based on the testing of 30 learners' data, the results obtained as in Table 1.

Table 1.30 Student's Learning Styles

ID	Learning Style	Total	Percentage
ASVQ	Active Sensing Visual Sequential	14	46,66667
ASVG	Active Sensing Visual Global	2	6,666667
ASBQ	Active Sensing Verbal Sequential	1	3,333333
ASBG	Active Sensing Verbal Global	0	0
AIVQ	Active Intuitive Visual Sequential	3	10
AIVG	Active Intuitive Visual Global	2	6,666667
AIBQ	Active Intuitive Verbal Sequential	2	6,666667
AIBG	Active Intuitive Verbal Global	0	0
RSVQ	Reflective Sensing Visual Sequential	1	3,333333
RSVG	Reflective Sensing Visual Global	0	0
RSBQ	Reflective Sensing Verbal Sequential	0	0
RSBG	Reflective Sensing Verbal Global	0	0
RIVQ	Reflective Intuitive Visual Sequential	0	0
RIVG	Reflective Intuitive Visual Global	0	0
RIBQ	Reflective Intuitive Verbal Sequential	0	0
RIBG	Reflective Intuitive Verbal Global	5	16,66667
Total		30	100

Based on the test, it revealed that the learning style of the most dominant learners is Active Sensing Visual Sequential of 46.7%. While each dimension has the dominant preference of each of the processing dimensions known active preference is dominant of 80%, perception dimensions are known sensing preferences of 67%, the input dimension is known dominant visual preferences of 70% and for the predominant dimension of understanding, preference is sequential of 73 %.

Detailed results from the processing dimensions are shown in Table 2, details of the perception dimension are shown in Table 3, details of the input dimension are shown in Table 4 and the detail of the dimension of understanding is shown in Table 5.

Table 2.Detailed of Processing Dimension

	ACTIVE	%	REFLECTIVE	%
Fairly Well Balanced	15	62,5	6	100
Moderated	8	33,33333	0	0
Very Strong	1	4,166667	0	0
	Total			
	24	100	6	100

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Table 3.Detailed of Perception Dimension

	SENSING	%	INTUITIVE	%
Fairly Well Balanced	13	65	8	80
Moderated	7	35	2	20
Very Strong	0	0	0	0
	Total			
	20	100	10	100

Table 4.Detailed of Input Dimension

	VISUAL	%	VERBAL	%
Fairly Well Balanced	17	80,95238	9	100
Moderated	4	19,04762	0	0
Very Strong	0	0	0	0
	Total			
	21	100	9	100

Table 5.Detailed of Understanding Dimension

	SEQUENTIAL	%	GLOBAL	%
Fairly Well Balanced	9	40,90909	4	50
Moderated	9	40,90909	4	50
Very Strong	4	18,18182	0	0
	Total			
	22	100	8	100

After the process of identifying learners' learning styles, the next step is to determine the ability level of the learners. The learners choose the ability level they have; the beginner (low), intermediate (medium) and advanced (high).

If the learner chooses the beginner level then no test will be done, the learner will be recorded in the database having a beginner skill level. When choosing advanced (high) it will be a computer-based test (CBT) with intermediate level material issues and if intermediate (medium) is selected CBT beginner level. The number of questions to be tested is 30 selected random orders as to minimize the possibility of cheats among learners. The limit value to meet a good level is 70 so that from 30 questions, at least 21 questions must true. For the test, learners are advised to choose an intermediate level. The results of intermediate-level learner tests are shown in Table 6.

Table 6.Test Result of Intermediate Level

Student ID	Score	Student ID	Score
1.	33,3	16.	13,3
2.	53,3	17.	50
3.	33,3	18.	43,3
4.	13,3	19.	23,3
5.	40	20.	33,3
6.	36,7	21.	33,3
7.	26,7	22.	33,3
8.	26,7	23.	43,3
9.	20	24.	26,7
10.	33,3	25.	66,7

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11.	40	26.	26,7
12.	33,3	27.	36,7
13.	20	28.	20
14.	56,7	29.	26,7
15.	40	30.	43,3

Based on the intermediate test results as in Table 6, it can be concluded that there is no learner who has intermediate level ability (medium) because the standard is 70. Therefore based on test result, all learners at beginner level and will begin learning process from the first material, the presentation of the material as shown in Fig 4.

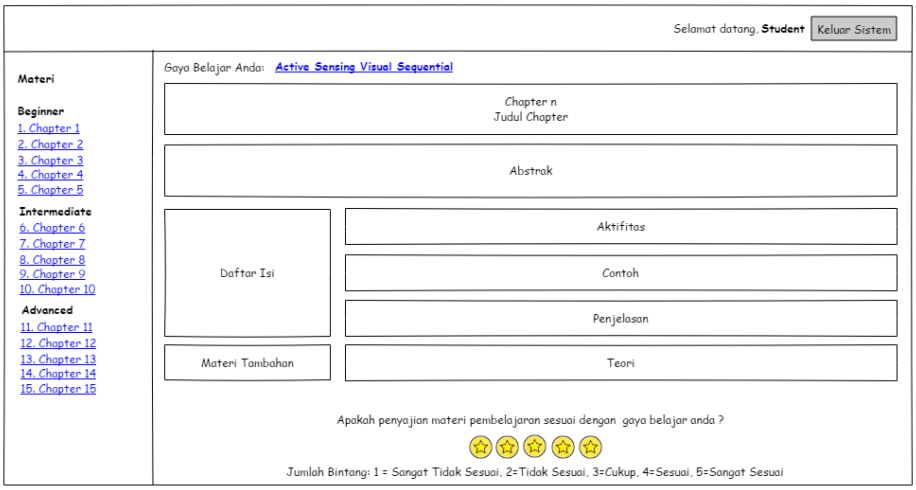

Figure 4: Presentation of the material based on learning styles and abilities

After identifying the learning styles and the ability level, the presentation of learning materials is prepared. Based on the previous stages, all participants tested have the same ability that is the beginner (base) with different learning styles. After learning materials are presented, learners are required to assess the material presented with learning styles, then to determine whether learners have understood the lesson they will be tested per material using CBT.

Beginner level has five learning materials, the level of understanding and the level of conformity of learning materials. Level of understanding obtained from the test results of learners, with a minimum value of sufficient or number 60. Level of suitability of the presentation of learning materials obtained from the input of learners using Likert scale (Very Suitable = 5, Suitable = 4, Enough = 3, Not Suitable = 2, Very Unsuitable = 1).
Testing students' understanding of learning materials is done at the end of each lesson per subject with CBT using 20 questions. The results obtained are shown in Table 7.

Table 7. Test result per material

Student ID.	Beginner Materials				
	1	2	3	4	5
1.	P	P	P	P	P
2.	P	P	P	P	P
3.	P	P	P	P	P
4.	P	P	NP	NP	NP
5.	P	P	P	P	P
6.	P	P	P	P	P
7.	P	P	P	P	NP
8.	P	P	P	P	P
9.	P	P	P	P	NP

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10.	P	P	P	P	P
11.	P	P	P	P	P
12.	P	P	P	P	NP
13.	P	P	P	P	P
14.	P	P	P	P	P
15.	P	P	P	P	P
16.	P	P	NP	NP	P
17.	P	P	P	P	P
18.	P	P	P	P	P
19.	P	P	P	P	P
20.	P	P	P	P	P
21.	P	P	P	P	P
22.	P	P	P	P	P
23.	P	P	P	P	P
24.	P	P	P	P	P
25.	P	P	P	P	P
26.	P	P	P	P	P
27.	P	P	P	P	P
28.	P	P	P	NP	NP
29.	P	P	P	P	P
30	P	P	P	P	P
Passed (P)	30	30	28	27	25
% of Passed	100	100	93.3	90	83.3

To measure the level of learners' suitability to the learning materials, learners fill out a questionnaire after the learning process with the question "Does the presentation of learning materials fit your learning style?". Learners fill in with Likert scale with scores (Very Suitable = 5, Suitable = 4, Enough = 3, Not Suitable = 2, Very Unsuitable = 1).
Ideal Scale: Score Criteria = Value of Scale x Number of Respondents. With the highest score 5 and the number of learners 30, it can be formulated as Table 8.

Table 8. Scale Score

Formula	Scale
5 x 30 = 150	VS
4 x 30 = 120	S
3 x 30 = 90	E
2 x 30 = 60	NS
1 x 30 = 30	VU

Based on the results, the level of learners' understanding on beginner level of learning materials is 93.32% and the level of suitability presented by the e-learning system is 86.66%, so it can be concluded that the learning materials presented by the system are appropriate as shown in Table 9.

Table 9. Student's Understanding and Suitability

Material	Understanding (%)	Suitability (%)
Material 1	100	90.7
Material 2	100	87.3
Material 3	93.3	86.7
Material 4	90	83.3
Material 5	83.3	85.3
Average	93.32	86.66

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V. CONCLUSION

Some conclusions have obtained as follows, this study produces the model of e-learning system in accordance with learning styles and the ability level of learners. The system model does not use the Learning Management System (LMS) that already exists in the market but developed its own system according to its needs.

Learning styles of learners are related to the presentation of learning materials. This study uses the Felder Silverman Learning Style Model (FSLSM) to identify the dominant learning style of learners through Index Learning Styles (ILS) in the form of a questionnaire consisting of forty-four questions divided into four dimensions, that each dimension consists of eleven question. To determine the ability level of learners, computer-based test or Computer Based Test (CBT) with Rasch model was used. The test is performed to determine the initial ability level (Beginner, Intermediate, Advanced) and determine the ability of each learning material. Recommendation rule from teachers was used to make recommendations of learning materials based on syllabus and lecturing unit that the presentation is adjusted with FSLSM.
Implementation and testing involved 30 students of Web programming course. Based on the results, the dominant learning style is Active Sensing Visual Sequential equal to 46.67% with the detail of each dimension is Active 80%, Sensing 67%, Visual 70% and Sequential equal to 73%, as to make e-learning and learning materials be focused on this learning style.

Based on the test, it is known that the initial ability level of 30 students is at beginner level. After doing the learning process and evaluate the level of understanding is 93.32%. The level of conformity is known at 86.66%.

The e-learning system model can be implemented to identify the dominant learning style of learners, the level of the learner's ability, presenting the learning materials based on recommendation-rule and evaluate the learner's ability level. This research involved one class of Web Programming courses, thus further research are needed to add accuracy and use parallel classes for the same course and different subjects as well as adding stages to identify learning styles based on the behavior while using the system by applying another algorithm.

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