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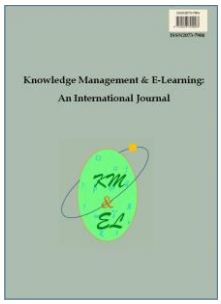

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Usability evaluation of personalized adaptive e-learning system using USE questionnaire

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Abstract: One of the advanced technologies in e-learning deals with the systems' ability to fit the students' preferences. It emerged based upon the common conception that every person has different learning style. However, despite the many options of learning style models toward using personalized e-learning, there are considerable challenges to assess the usability degree of the e-learning. The aim of this study is the evaluation of usability of personalized adaptive e-learning system that has been developed based on students' learning style and initial knowledge level. The study involved 62 Computer Network students in one of the public vocational secondary schools in Yogyakarta, Indonesia. To measure the usability, the USE Questionnaire, which consists of four indicators (usefulness, ease of use, ease of learning, and satisfaction) represented by 30 questions with four possible Likert scale options, was distributed to the students. The research finding indicates at first the usability of the adaptive e-learning system for the students was well accepted in all aspects of usability. Next, the multiple linear regression result showed that the variables usefulness, ease of use, and ease of learning simultaneously influence satisfaction. Lastly, the regression results also revealed that the variables usefulness and ease of use partially influence satisfaction, while the variable ease of learning does not.

Keywords: Usability evaluation; Personalized e-learning; Adaptive e-learning; USE questionnaire

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1. Introduction

The development and growth of Information and Communication Technology (ICT) are rising rapidly, especially in Indonesia. Nowadays, all aspects of society are affected by the ICT, including in the education sector. According to the survey conducted by the Indonesia Internet Service Provider Association in 2017 (APJII, 2017), the penetration of internet use in Indonesia significantly increased from year to year. APJII also reported that in 2017, there are 54.68% (143.26 million from 262 million) of Indonesian populations who have accessed internet. Furthermore, the data also evidenced that 16.68% of internet users are at the secondary school age (13 to 18 years old). From the data mentioned, we must conclude that the internet use in Indonesia is at a significant number especially in the secondary school age. It needs some strategy to utilize the internet for educational purposes rather than for non-educational one. Thus, such internet strategy can be adopted by trainers, researchers or policymakers to maximize the utilization of internet technology in the learning process. Subsequently, it can be considered to overcome recent limitations by developing and utilizing e-learning.

The term e-learning is an abbreviation for electronic learning which means the education process by utilizing electronic devices or digital media (Köhler & Ihbe, 2006). Already earlier Clark (2002) stated that e-learning is content and instructional methods delivered on a computer (whether on CD-ROM, the internet, or an intranet), and designed to build knowledge and skills related to individual or organizational goals. Another researcher who also has the same opinion, Koohang (2004), he defines e-learning as the applications and processes such as web-based learning, computer-based learning, virtual classrooms, and digital collaboration which deliver its content via internet, intranet/extranet, audio or video tape, satellite TV, and CD-ROM. Furthermore, the e-learning researchers at the National Center for Supercomputing Applications (NCSA) of the University of Illinois at Urbana-Champaign, use terms such as web-based learning, online learning, technology-based learning, and distributed learning are synonymous to e-learning (Wentling et al., 2000). Remarkably, all of the definitions mentioned have a same key factor in the use of internet or intranet as a medium to transfer the learning content.

One of the state-of-the-art technologies in e-learning is personalized e-learning. This comes from the common conception that each student differs from one to another. One student cannot be treated the same as another since every student has his or her own preferences and strengths in learning (Dunn, 1990). Commonly, in many schools, it is likely for each student in a group to have distinctive preferences in learning (Hariyanto & Köhler, 2017b). Many studies have been conducted to make an instrument to classify student learning styles (Briggs, 1976; Felder & Silverman, 1988; Fleming & Mills, 2001; Honey & Mumford, 1992; Kolb, 2004; Hruska-Riechmann & Grasha, 1982; Dunn & Dunn, 1979). The student learning style is one of the many criteria that can be used as an input to make e-learning adaptive for each user. Other criteria that have already been implemented and studied are the knowledge state (Alshammari, Anane, & Hendley, 2015; Klašnja-Milićević, Vesin, Ivanović, & Budimac, 2011; Mitrovic, 2003), cognitive style (Triantafillou, Pomportsis, & Demetriadis, 2003), learning behaviors (Tseng, Chu, Hwang, & Tsai, 2008), and learner performance (Jeon & Su, 2011). All of these studies indicated that the implementation of e-learning by considering different student preferences had a positive outcome.

The personalized e-learning used in this study was designed based on two criteria of adaptation instead of a single criterion (Hariyanto & Köhler, 2017a). The criteria that are used as parameters for the adaptivity in the system are the student learning style and initial knowledge level. Both criteria drive the e-learning system to fit the learner characteristics automatically. Previous studies in the use of multiple criteria have indicated that the adaptability in the e-learning system was more promising to capture learner preferences (Alshammari et al., 2015; Tseng et al., 2008; Yang, Hwang, & Yang, 2013).

One factor that should be considered is to ensure that the particular e-learning system is usable and meets the users' needs. Hence, this requires an assessment or evaluation to determine whether the e learning application is usable and suitable for use. The evaluation of computer-based e-learning can be conducted in the context of software engineering (Jogiyanto, 2005; Pressman, 2005), expert review (Nielsen, 1992, 1994), or end-user perception (Dix, Finlay, Abowd, & Beale, 2004). It is common sense that e-learning as a computer-based application has a strong interaction with end users. Hence, one discipline that is closely rated to this phenomenon is Human-Computer Interaction (HCI). In HCI theory, usability is an essential key issue since it is an aspect that refers to the quality of the user interface (Parlangeli, Marchigiani, & Bagnara, 1999). Usability evaluation is concerned with gathering information about the usability of the system to assess it by collecting the users' perspectives via many methods (e.g., thinking aloud, field observations, and questionnaires) (Holzinger, 2005). Other techniques to measure usability are interviews (Olsen, 2002), focus groups (Nielsen, 1997), and most of the widely used standardized usability questionnaire (Assila, de Oliveira, & Ezzedine, 2016). A typical multi-method approach was also applied by Kahnwald and Köhler (2009), who combined online user questionnaires with expert-based opinions to find insightful differences between usability, utility, and learnability. Those varieties of usability evaluation techniques have the same main objective of capturing user perceptions about the user interfaces and then determining user satisfaction.

While online-based testing plays an increasingly important role in higher vocational education (Mabed & Köhler, 2018), the primary purpose of this study is to present the empirical study of the usability evaluation regarding the personalized adaptive e-learning system by considering multiple criteria. The first criterion used in e-learning is the learning style constructed explicitly in the context of the engineering field. The Felder and Silverman Learning Style Model (FSLSM) is one of the most widely used models

that attempts to address that issue (Kapadia, 2008). The FSLSM was chosen because this e-learning will be implemented for vocational students. The FSLSM classifies individual learning style preferences across four dimensions (i.e., active-reflective, sensing-intuitive, visual-verbal, and sequential-global) (Felder & Silverman, 1988). The dimensions offered by the FSLSM perfectly accommodate the student learning styles in detail. Another criterion for adaptation is the knowledge state. The knowledge state criterion has performed well in many adaptive e-learning studies (Alshammari et al., 2015; Klašnja-Milićević et al., 2011; Mitrovic, 2003). Furthermore, the usability evaluation is done by conducting the USE (Usefulness, Satisfaction, and Ease of Use) Questionnaire, which comprises the attributes of usefulness, ease of use, ease of learning, and satisfaction (Lund, 2001). In addition, the second aim of this study is to explore the correlations between the attributes of the USE Questionnaire. Therefore, the following research questions are explored to address the research objectives:

- To what extent do the students find the personalized adaptive e-learning system usable?
- To what extent are the attributes of the usability questionnaire correlated?

2. The personalized adaptive e-learning system

The basis of the personalized adaptive e-learning system used for the usability evaluation in this study is the system that we have been designed and developed in previous research (Hariyanto & Köhler, 2016, 2017a). The adaptation parameter used in the e-learning system is students' learning style and initial knowledge level. The first parameter, the learning style, is initialized by utilizing the Felder and Silverman model which constructed specifically for engineering students (Felder & Silverman, 1988). To obtain the learning style information, the Index of Learning Style (ILS) questionnaire which created by Felder and Soloman was administered to the participants (Soloman & Felder, 2005). The second parameter is the information regarding students' initial knowledge which initialized by using a pre-test. The pre-test is constructed in a multiple-choice model that corresponds to a certain topic in e-learning.

Fig. 1 shows the screenshot of adaptive e-learning system. Basically, the system is divided into three important areas. The first, which is located on the left side, is the navigation area. This area contains the links representing the course units and sub-units. For the global learner, the navigation area will provide the links of units and sub-units to present a brief overview related to the course. While for the sequential learner, the sub-units links will automatically disappear. They only show the units links. The sequential type user can explore the material by using the next and previous button sequentially. The second area is located in the middle. This area is called the fundamental content area. This area can accommodate presentation of the learning material in whether visual or verbal learner type. The third area is the additional content area which located on the right side. The learning material presented in this area is depending on the students' learning style. For the visual learner type, the information will provide mostly in visual media formats such as image, video, animation. Otherwise, for the verbal learner type, it will present the material mostly in verbal media formats such as text, audio. There are some buttons attached to the top part of this area. The function of those buttons depends on the active-reflective and sensing-intuitive dimensions of students' learning style. When a particular button is clicked, the floating window will present the learning object related to a particular button. The set of rules mentioned in our previous research was

made as guidance for the system to automatically show the learning object related to the active-reflective and sensing-intuitive dimensions (Hariyanto & Köhler, 2017a).

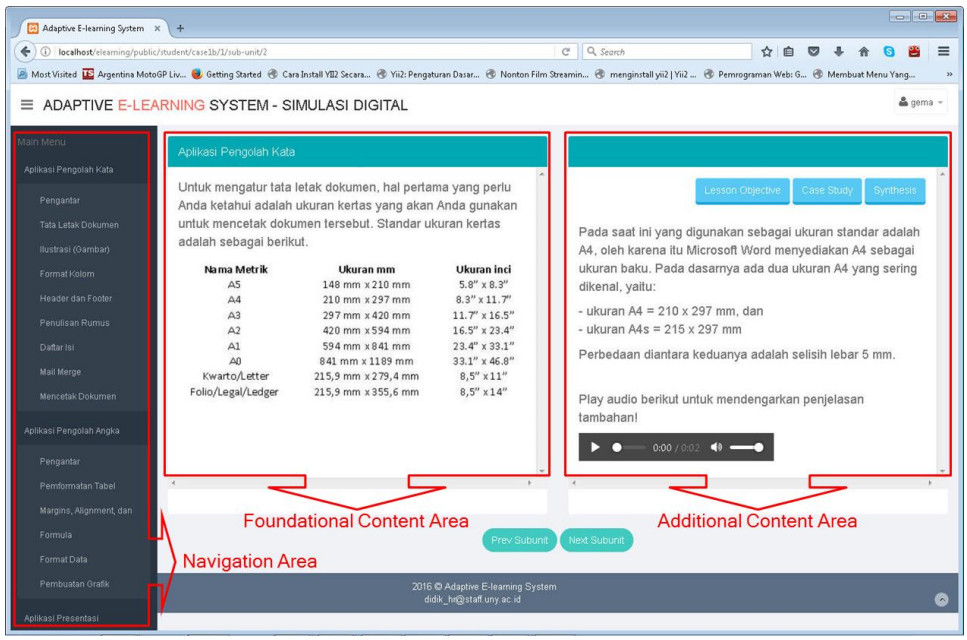

Fig. 1. The user interface of adaptive e-learning system

The second parameter is the information regarding students' initial knowledge which is initialized by using a pre-test. The pre-test is constructed in a multiple-choice model in correspondence to a certain topic in e-learning.

The functional testing or black box testing is an essential element in software development in order to assure the system free from bugs and act as designed (Luo, 2001; Williams, 2006). The functional-based test conducted to the e-learning system by administering some different test input to the system. By observing the behavior of the system when the system provided a certain input, the test results indicated that the adaptive e-learning system could react as its designed by automatically changing the learning environment and learning path based on user's learning style and initial knowledge (Hariyanto & Köhler, 2017a).

3. Usability evaluation

There are a number of methods and questionnaires have been used for evaluating or assessing usability of the technological products based upon the user perception. Some of the most well-known are the Questionnaire for User Interaction and Satisfaction (QUIS) (Chin, Diehl, & Norman, 1988), the Software Usability Measurement Inventory (SUMI) (Kirakowski & Corbett, 1993), the Computer System Usability Questionnaire (CSUQ) (Lewis, 1995), the questionnaire System Usability Score (SUS) (Brooke, 1996), and the USE questionnaire (Lund, 2001).

Developed by a multi-disciplinary team at the University of Maryland, the QUIS is a general user evaluation tool for assessing interactive computer systems (Norman, Shneiderman, & Harper, 1995). This questionnaire is relatively long and divides the

usability measurement into many specific aspects. Another instrument, the SUMI, is a proven questionnaire to measure software quality from the perspective of end users. It consists of as many as 50 statements based upon the definition of usability described in ISO 9241. Although it offers a complete report and is available in many languages, the user must purchase it to obtain these benefits (Kirakowski & Corbett, 1993). The CSUQ was designed by Lewis (1995) and is freely available with a public license. It has excellent reliability (the coefficient alpha typically exceeds 0.90), but it lacks a standard (Faria, Pavanelli, & Bernardes, 2016).

One of the widely used models is the SUS, which was proposed by Brooke (1996). The SUS is created based on the demands of evaluating the usability of the systems which do not require much effort and expense to collect and analyze data. The SUS is a simple, composed of ten-item questionnaires with the possibility to response on 5 points Likert scale ranging from "strongly agree" to "strongly disagree." The SUS statements give a global view of the subjective assessment of usability and provide a final single score on a scale that is easily understood. Though SUS is a valid and reliable metric to measure the usability (Orfanou, Tselios, & Katsanos, 2015), but SUS is only created based on a single dimension, on the other hand, it needs an instrument that can be used to assess the usability in more detail, comprises of two or more dimensions. As defined by the International Organization for Standardization (ISO) 9241, usability is the degree to which a particular product can be used by particular users to accomplish specified goals with considering effectiveness, efficiency, and satisfaction in a specified circumstance of use (ISO, 1998). Meanwhile, Nielsen (1994) mentioned that usability comprises multiple components, namely learnability, efficiency, memorability, errors, and satisfaction. Therefore, it can be considered that, a more comprehensive assessment of the usability requires the consideration of many attributes.

There are other related models that consider many dimensions such as the USE Questionnaire which was introduced by Lund (2001). Initially, the USE Questionnaire composed of three dimensions, Usefulness, Satisfaction, and Ease of Use. The study found that there is a significant correlation between Usefulness and Ease of Use where the improvements in Usefulness influence the scale of Ease of Use and vice versa. Meanwhile both dimensions affect Satisfaction. For the specific situation, the items on Ease of Use could be separated into two dimensions, Ease of Use and Ease of Learning where both were obviously highly correlated (Lund, 2001).

As stated by Faria et al. (2016), the evaluation dimensions in the USE Questionnaire were believed to be the most important factors to evaluate usability. The construction of the items was aimed to make the items as simply worded and as general as possible to easily be understood by respondents (Lund, 2001). Consequently, the questionnaire can be used with little training. Although the development of the questionnaire is still continuing, the questionnaire has been used successfully by many researchers (Faria et al., 2016; Filippidis & Tsoukalas, 2009; Hashim, Hussin, Othman, & Ahmad, 2016; Kiselev & Loutfi, 2012; Salameh, 2017). The other essential reason for its use is that researchers do not need to purchase it to use the questionnaire because it has a public domain license (Faria et al., 2016). The public domain license means that each person could use the material freely by maintaining the attribution to the original author. This is an appropriate choice for practitioners and researchers who need to conduct a usability evaluation without use or tabulation fees. It is also important to consider that the respondents sometimes become bored and lack focus when they are exposed to too many questions. Alternatively, the minimal number of questions often causes difficulties in providing enough information. Accordingly, this instrument is the best choice because it is composed of a reasonable number of items (30 items).

4. Research design

We observed the usability of adaptive e-learning system that we designed and developed. The e-learning system used in this study has the ability to automatically adapt the learning path and learning environment based on the criteria of learning style and initial knowledge of the students. In order to evaluate the usability of the e-learning system, we decided to implement USE Questionnaire.

4.1. Instrumentation

In this study, we used the USE Questionnaire to measure the usability of the e-learning system. Since the USE Questionnaire was originally developed in English language, it needs to be translated and transferred into an Indonesian version in order to provide the questionnaire to be easily understood by the respondents. The translation process was done by a credible translator from the language center. With consideration of certain aspects of the items meaning, the questionnaire was compiled into a final version.

The USE Questionnaire is divided into three independent variables (usefulness, ease of use, and ease of learning) and one dependent variable (satisfaction). A conceptual model of the relationship among the variables can be seen in Fig. 2.

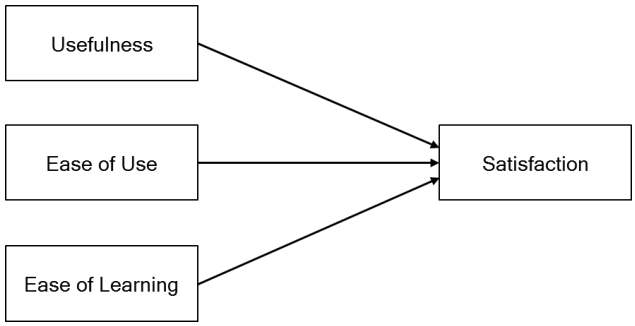

Fig. 2. The conceptual model of USE questionnaire

Within the questionnaires, a total of 30 questions are represented in four variables. Originally, all of the questions in the USE Questionnaire were constructed in the positive wording format. Since there is a tendency that sometimes the respondents make a response bias and acquiescent bias, three of the questions were reversed into the negative wording. By combining both positive and negative items, it could force the respondent to consider each question and hopefully provide a right response. A 4-point Likert scale is used in this instrument where point 1 stands for “strongly disagree” and 2 for “disagree” while point 3 for “agree” and 4 for “strongly agree.” The outline of the questionnaire showed in Table 1.

Other than that, there is a blank space positioned in the last part of the questionnaire for the participants to give comments. The comments can provide by the participants on the basis of open-ended feedback. The participants may give either comments or suggestions after they experienced the learning process through the adaptive e-learning system provided. The data collected from the user-based comments can be considered qualitative data. This qualitative data serves to support the main focus of analyzing the quantitative data that has been collected via the Likert-scale responses.

Table 1
Outline of the USE questionnaire

No	Variables	Items Number	Total Items
1	Usefulness	1, 2, 3, 4, 5*, 6, 7, 8	8
2	Ease of Use	9, 10, 11, 12, 13, 14*, 15, 16, 17, 18, 19	11
3	Ease of Learning	20, 21, 22, 23	4
4	Satisfaction	24, 25, 26*, 27, 28, 29, 30	7

Note. * = Negative question

4.2. Participants

The study involved 62 students of Public Vocational High School 2 Pengasih, Kulon Progo in Yogyakarta Province, Indonesia. Since all participants were from the Department of Computer Network Techniques, it could be assumed that they all had good basic knowledge and experience for using computer and software systems. Among the respondents, 80.65% were male (50 students) while 19.35% were female (12 students).

4.3. Procedure

The study lasted for roughly 3 hours in the computer laboratory of Computer Network Department. The total number of students who participated in this study was 62 students. In the first session, the participants were given a brief explanation about the main objectives of the study, the e-learning system, and its features, and informed how to operate it. The demonstration of the application also showed to the participants. The participants were allowed to ask when they meet the problems or difficulties to use the application. The next session, the students were asked to access the system with the login information we were distributed before. In the first window, the students should take the multiple choices pre-test and follow by completing the ILS (Soloman & Felder, 2005) questionnaire based on the Felder-Silverman model. After the completion of test and questionnaire, the e-learning system was provided the personalized learning path and learning environment based upon the previous test and survey. They had opportunities to explore the content and to try the learning path provided. At the end of the learning process, the paper-based USE Questionnaire (Lund, 2001) is distributed to the students. They were asked to read the questions carefully and to choose one of the four-point Likert scale refers to the questions. The illustration of the research procedure can be seen in Fig. 3.

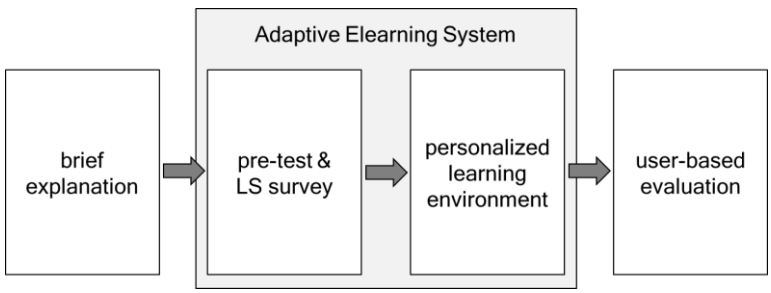

Fig. 3. The research procedure

5. Result

5.1. Validity and reliability of USE questionnaire

Validity is the extent to which the assessment tool accurately measures what it is supposed to measure. The validity was evaluated using Pearson correlation. If the correlation value is greater than *r* table, then the instrument could be considered valid, and vice versa, the instrument is decided invalid if the correlation value is less than *r* table. As shown in Fig. 4, all correlations value for each question (Q1 to Q30) was higher than *r* table (0.250) in the significance level of 0.05. Hence, the measure for each question satisfies the validity criteria.

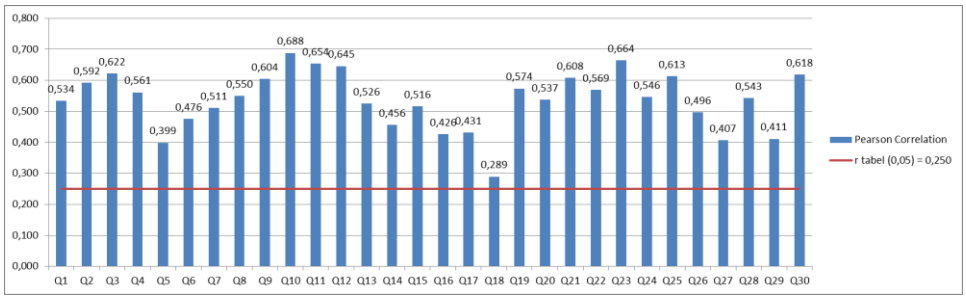

Fig. 4. The bar chart of validity test

Reliability is the extent to which the assessment tool produces stable and consistent results. The reliability was examined using the Cronbach's alpha values. It is generally agreed that the instrument could be considered reliable when the cutoff value of Cronbach's alpha is minimum 0.7 (Landauer, 1997; Nunnally, 1978; Robinson, Shaver, & Wrightsman, 1991). As shown in Table 2, all of the construct items (usefulness, ease of use, ease of learning, and satisfaction) exhibited higher than 0.7. Therefore, we conclude that the scores of Cronbach's alpha for all construct are within the acceptable criteria.

Table 2
Reliability statistics

Variables	Cronbach's Alpha	N of Items
Usefulness	0.770	8
Ease of Use	0.792	11
Ease of Learning	0.717	4
Satisfaction	0.703	7

5.2. Usability measurement score

Nielsen (1994) mentioned that one method to describe the result of the usability measurement typically takes the mean value of each variable used. According to this study, the mean scores on usefulness, ease of use, ease of learning, and satisfaction are respectively 3.22, 3.19, 3.28, and 3.19 on a four-point Likert scale (see Table 3). How to decide whether the mean scores categorized as accepted or unaccepted is based upon the dichotomously justification to the direction of response (Babbitt & Nystrom, 1989).

When the direction of response is going to the degree of agree or strongly agree, it means that the measurement in certain variable is acceptable, otherwise, if the direction of response is going to the opposite one (disagree or strongly disagree), it indicates that the assessment is unacceptable. As it was also conducted by Marreez et al. (2013), he converted the Likert score to "binomial data" by deciding to accept and reject categories according to agree and disagree responses from the participants. The score 4 (strongly agree) and score 3 (agree) categorized as accept and score 2 (disagree) and score 1 (strongly disagree) categorized as reject or not accept (Marreez et al., 2013). The same situation will have the same result when the score is converted into a typical school score of the range 0 to 100. The converted scores from the mean score for usefulness, ease of use, ease of learning, and satisfaction are 74.13, 73.07, 75.94, and 72.89, respectively. The positive limit of acceptable usability of the system is 50 (Debevc & Bele, 2008). When the score exceeds 50, it means acceptable and otherwise unacceptable or unsatisfactory.

Table 3
Mean score and 0-100 score

Variables	Mean Score	0-100 Score
Usefulness	3.22	74.13
Ease of Use	3.19	73.07
Ease of Learning	3.28	75.94
Satisfaction	3.19	72.89
Average Score	3.22	74.01

From the results aforementioned, it can be concluded that the system is well accepted in general. All of the scores in four variables have the score exceeded 50; it means that the usefulness, ease of use, ease of learning, and satisfaction are accepted. When it takes a look in average score from four variables, as representative of usability, the score is 74.01 which also exceeded 50. Thus, the usability of the proposed system is accepted by the user. The score 74.01 from the average score of the USE Questionnaire collected from the students, it could be assumed that 74.01% of the students expressed their satisfaction to the usability of the e-learning system. When there are 100 students for instance involved in the study, it means that 74.01 students are satisfied with the system and fell that the system is accepted to be used for its purpose.

5.3. User open-ended feedback

The user feedback in the form of comments or suggestions was also collected. The participants could express what they felt when they used the e-learning application on the basis of open-ended feedback. From the 62 students that participated in this study, eight students did not give feedback on the adaptive e-learning implementation. The remaining 54 students provided diverse comments. Forty-one students responded positively to the utilization of the adaptive educational software. The most frequent positive comments can be seen below:

- "The adaptive e-learning application was useful for students to learn the course material."
- "The adaptive e-learning application was easy to use."

- "The adaptive e-learning application could help the students to be more effective in studying."

Three students stated that they were not satisfied with the e-learning application to some extent, as described by the comments below:

- "There was still found a software bug."
- "The interface of the adaptive e-learning application was not interesting."
- "The course material prepared was not comprehensive enough."

Nine students mentioned both positive remarks and the shortcomings of the e-learning implementation, as described by the comments below:

- "The adaptive e-learning application was helpful. But I spent too much time to be used to it."
- "The adaptive e-learning application was good for studying, but the interface was not attractive."

Although most comments implied the acceptance by the students of the implementation of e-learning, drawbacks were still found. One student mentioned a software bug. It could be any kind of error because no specific bug was mentioned. As specified by Jogiyanto (2005), the coding errors could be syntax errors, run-time errors, or logical errors. However, it was verified that the e-learning software had already been checked and declared to well work functionally (Hariyanto & Köhler, 2017a). However, there is still a need to check the e-learning system comprehensively.

Concerning the appearance of the e-learning user interface, many students thought that the e-learning website was acceptable. However, a few students felt that the e-learning website was not interesting. Five students commented and gave suggestions to modify the e-learning website to be more attractive. They suggested providing more instructional videos and subject-related games. Focused on the e-learning navigation, most students did not have any problems, but there was one special case where a student needed some more time to become used to it. Regarding the content, although the other students had no complaints on the course material, one student said that the course material was not comprehensive enough. He asked to facilitate the e-learning with more learning resources.

5.4. Multiple linear regression prerequisites

Hair et al. (2009) states that multiple linear regression analysis is used to analyze the relationship between two or more independent variables and a single dependent variable. The regression analysis will result in the regression equation or regression model. Prior to the analysis of multiple linear regression, there are the classical assumptions regarding the variables used that should be tested. These tests should be taken into account in order to make the results more trustworthy. The variables used in the study should meet normal distribution, there is no multicollinearity, there is no heteroscedasticity, and autocorrelation.

5.4.1. Multivariate normality test

The first assumption, a multiple linear regression analysis requires that the variables should be normally distributed. This assumption may be checked by looking at the

residual data plot. As shown in Fig. 5, the data plot of this research show that the points of the data follow the straight line and there is no significant deviation toward normal plot. Thus, it indicates that the residual is in a normal distribution.

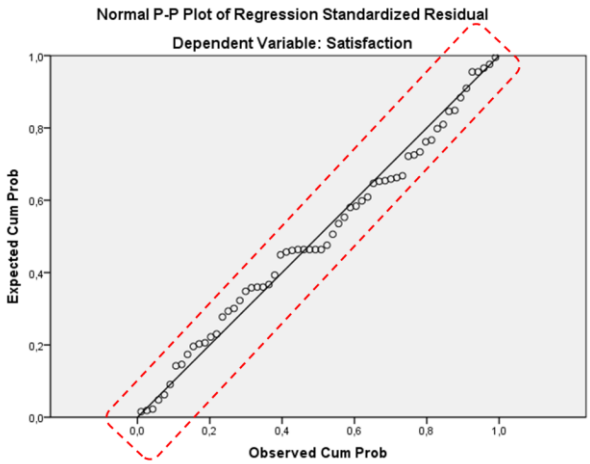

Fig. 5. Normality test data plot

5.4.2. Multicollinearity test

Second, a model of multiple linear regression assumes that there is no multicollinearity in the data. Multicollinearity can occur when there is a high correlation among the independent variables. Multicollinearity can be observed from the Variance Inflation Factor (VIF) and Tolerance. The criteria for no multicollinearity is found in the data if each independent variable has VIF below 10 (VIF < 10) and Tolerance greater than 0.1 (Tolerance > 0.1). Based on the multicollinearity test as shown in Table 4, we can see that VIF for usefulness (1.906), ease of use (2.683), and ease of learning (2.332) are smaller than 10 and Tolerance for usefulness (0.525), ease of use (0.373), and ease of learning (0.429) are above 0.1. Thus, we can conclude that all independent variables are free of multicollinear or no correlation exists between each variable.

Table 4
Multicollinearity test table

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Usefulness	.525	1.906
	Ease of Use	.373	2.683
	Ease of Learning	.429	2.332

Note. a. Dependent Variable: Satisfaction

5.4.3. Heteroscedasticity test

The last assumption of multiple linear regression is homoscedasticity. One of the best ways to check this assumption is by visual examination of a scatter plot of residuals versus predicted values. Ideally, residuals are randomly scattered above and below or around 0 (the horizontal line). There should be no specific pattern in the distribution, such as a bowtie or cone shape. Fig. 6 shows the scatterplot of residuals that meet the criteria mentioned earlier. Thus, we can conclude that there is no heteroscedasticity in the regression model, or the model fulfills homoscedasticity.

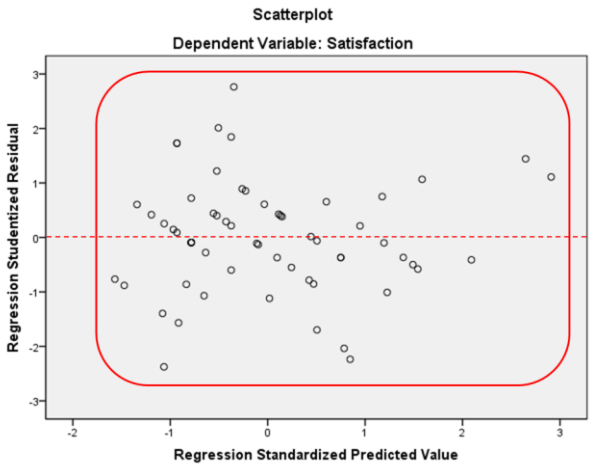

Fig. 6. Homoscedasticity test scatterplot

5.5. Multiple linear regression analysis

Based on the previous classical assumptions test, it is concluded that all model assumption has fulfilled the criteria. Therefore, the multiple linear regression analysis can be performed. Multiple linear regression is used to explain the relationship between two or more independent variables and one dependent variable.

5.5.1. F test

The F test is used to analyze whether the independent variables simultaneously influence the dependent variable. As shown in Table 5, the Sig. value is 0.000 which is less than the significant level 0.05 (0.000 < 0.05), this means that the Sig. value meet the criteria. Meanwhile, the F statistic (30.288) is greater than F table (2.764). Therefore, it indicates that the independent variables (usefulness, ease of use, and ease of learning) simultaneously influence the dependent variable (satisfaction).

5.5.2. Partial t-test

The *t*-test is used to analyze whether the independent variables partially influence the dependent variable. The results of Table 6 show that the independent variable (usefulness) has Sig. value 0.036 that is smaller than the significance level (0.05) and *t* value (2.143) is greater than *t* table (2.00). This states that usefulness has a significant influence on

satisfaction. The second independent variable (ease of use) also has a significant influence on satisfaction which the Sig. value (0.000) less than the significance level (0.05) and *t* value (4.657) exceeds *t* table value (2.00). Meanwhile, the independent variable (ease of learning) has Sig. value 0.775 above the significance level (0.05). It indicates that ease of learning has not a significant influence on satisfaction.

Table 5
F test table

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	141.106	3	47.035	30.288	.000[a]
	Residual	90.071	58	1.553		
	Total	231.177	61			

Note. a. Predictors: (Constant), Ease of Learning, Usefulness, Ease of Use;
b. Dependent Variable: Satisfaction

Table 6
t-Test table

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.990	2.040		1.466	.148
	Usefulness	.199	.093	.242	2.143	.036
	Ease of Use	.423	.091	.625	4.657	.000
	Ease of Learning	-.053	.183	-.036	-.287	.775

Note. a. Dependent Variable: Satisfaction

6. Discussion and conclusion

The study aimed to evaluate the usability of personalized adaptive e-learning system which was used in one of the public vocational secondary schools in Indonesia. The e-learning system used in this study had the ability to adapt to students' preferred learning styles and students' initial knowledge. The learning environment and learning path of the e-learning system could automatically change to fit the students' preferences. The evaluation was done by using USE Questionnaire which delivers four parameters assessment, covering namely usefulness, ease of use, ease of learning, and satisfaction. The analysis of the results showed that USE Questionnaire was a valid and reliable tool for the assessment of e-learning usability. The validity check indicated that all of the question items were on valid criteria. Furthermore, the reliability of all variables included in the questionnaire exceeded the minimum threshold. These results were in line with many studies that have been conducted to assess the usability of educational applications (Filippidis & Tsoukalas, 2009; Hashim et al., 2016; Lund, 2001; Salameh, 2017).

Since adaptive e-learning was developed in the frame of software engineering, it is essential to ensure that the system can functionally work without any critical errors. Concerning error checking in the software application, Jogiyanto (2005) classified three common errors that are generally revealed in software coding: 1) syntax errors, 2) run-time errors, and 3) logical errors. Furthermore, software testing can be divided into black-box testing or white-box testing (Pressman, 2005). Luo (2001) referred to black-box testing as functional testing. This test focuses only on the outputs generated by the system with certain inputs. This test ignores the internal mechanism of a system or component (Radatz, Geraci, & Katki, 1990). Meanwhile, Luo (2001) stated that white-box testing is structural testing. According to Radatz et al. (1990), the structural test considers the internal mechanism of a system or component. Williams (2006) implied that one basic test that should be conducted for software testing is black-box testing.

At this point, the error checking suggested by Jogiyanto (2005) has been implemented, and several errors that had been found were minimized. The black-box testing advised by Williams (2006) has also been conducted and resulted in good performance. From this software evaluation aspect, the adaptive e-learning used in this study was considerably ready to use to a certain extent (Hariyanto & Köhler, 2017a). The readiness of the instructional software may allow the students to gain the benefits offered by the system.

The quantitative data were collected through the Likert-scale USE Questionnaire. The results showed that, for each variable, the assessment could reach a significant score. Based upon the dichotomous justification (Babbitt & Nystrom, 1989), "binomial data" assessment (Marreez et al., 2013), and typical school score evaluation (Debevc & Bele, 2008), the results were graded in the category of accepted. The average score from the four variable assessments reached 74.01 from a maximum of 100 for the typical school score evaluation. Thus, it performed above the acceptable usability threshold (Debevc & Bele, 2008). Therefore, the users feel satisfied with the personalized e-learning system.

Bangor, Kortum, and Miller (2009) made a scale of acceptability ranges for assessing the usability score. Although that scale was created based on the SUS score, it is possible to adapt it to assess other usability scores including the USE score. According to the scale made by Bangor et al. (2009), the score from this study is categorized in the acceptable range, which exceeds the acceptance threshold of 70. Moreover, the score that arose from this study can also be classified as a "good" grade in terms of the adjective ratings (Bangor et al., 2009).

To cross-validate the quantitative data, the open-ended feedback from the participants was also collected and verified. From the number of students who responded positively in the implementation of the adaptive e-learning application, 41 students out of 62 (66.13%) could be classified as satisfied. This finding confirms the conclusion from the previous Likert-scale measurement score, especially in the satisfaction variable. It scored particularly high in the satisfaction variable, and 72.89 (see Table 3) was in the acceptable range. This score was compared with the positive feedback (66.13%), which was also in the acceptable criteria based on Debevc and Bele (2008). Therefore, the data from both the Likert scale (representing the quantitative data) and the open-ended feedback (representing the qualitative data) can be categorized at the same level, which is an acceptable level.

Observing the positive comments exposed more detail. Three keywords represented the thoughts of the students: useful, easy to use, and effectiveness. These three keywords represent a positive assessment by students of the e-learning application. The first two keywords could assume an acceptable confirmation of the two variables of

the USE Questionnaire, (i.e., useful and easy to use). The keyword "effectiveness" is in line with the first factor that should be fulfilled according to the usability evaluation from the ISO 9241 standard.

In contrast to the overall satisfying results, some of the open comments revealed some crucial problems with the usability of the e-learning application. For instance, there was still a bug found in the software. Even though most of the students did not detect any bugs, this still requires a more specific investigation concerning the software coding. Furthermore, other comments indicated that the e-learning user interface needed to improve to be more attractive. There were no specific complaints concerning the e-learning appearance. However, a few of users suggested furnishing the instructional material with more videos and games. In addition, more learning material was requested to make it more comprehensive. Furthermore, one student complained about spending too much time to become used to the e-learning environment, and another student said that the navigation button was not located in an appropriate place.

Web-based e-learning has a strong relationship with issues regarding the internet connection and computer literacy. Some studies have reported that internet access is the most challenging concern in online courses (Guspatni, 2018; Qureshi, Ilyas, Yasmin, & Whitty, 2012; Sohrabi, Vanani, & Iraj, 2019; Stark, Lassiter, & Kuemper, 2013). Low internet bandwidth and network infrastructure problems are often faced by the user in accessing a website. In this study, there were no comments regarding the internet connection problem since the e-learning we designed was in the frame of a Local Area Network (LAN). This technique may transfer the data faster than a Wide Area Network (WAN). In a LAN, it is possible to put the computer server in the same area as the computer user. As a benefit, it does not require spending money to rent a specific internet domain and host. However, e-learning will only work on the LAN. From this point, the e-learning creator can consider this strategy to minimize the potential problems concerning the internet connection.

Concerning the computer literacy issue, Croxall and Cummings (2000) stated that the skill level in using a computer is an essential factor in the successful adoption of technology. The experienced users of the internet and computers may accept and use e-learning quickly (Picciano & Seaman, 2007). As the users in the current study were registered in the Computer Network Department, it can be assumed that they have had experience with the internet and computers; hence, computer literacy was not an issue.

However, there was one anomaly regarding this issue from a student who had difficulties becoming used to the e-learning environment. Therefore, training for e-learning users is an important aspect before using e-learning in the educational process. Technical training not only for the students as users but also for the teacher as a content administrator is a crucial step to support user acceptance of the e-learning system. The technical training can primarily consist of how to ensure users and administrators become familiar with the system. The possible failure that emerged in the system and a way to deal with it also must be explained thoroughly.

Furthermore, a multiple linear regression analysis was conducted to observe the relationship among variables involved in the survey. All of the model assumptions met the standard prerequisite criteria prior to the regression analysis. The regression showed that the usefulness and ease of use partially affected satisfaction. As mentioned by Davis (1989), there were two aspects that are fundamental determinants of the system utilization, namely usefulness and ease of use.

Usefulness defines the degree to which a user believes that using a certain system would improve his or her job performance positively. From this point, it is a common belief that when people have a positive enhancement in performance, it will lead to satisfaction. In contrast, decreasing performance may cause dissatisfaction. Therefore, the aspect of usefulness can considerably influence the satisfaction level when someone is utilizing a particular system. This hypothesis supports the finding of this study in which usefulness has a significant effect on satisfaction.

Meanwhile, ease of use refers to the degree to which a user believes that using a certain system would be effortless. The easier it is to use a particular system compared to another system, the more likely it is to be accepted by users and may lead to the user feeling satisfied. This theoretical construct also supports the current study finding in which ease of use has a significant effect on satisfaction.

Surprisingly, the *t*-test found that the ease of learning has no significant influence on satisfaction. Lund (2001) stated that ease of use could be separated into two factors: ease of use and ease of learning. Whereas ease of use is more focused on the level of ease for using the system, ease of learning is concentrated on the level of effort allocated to learn the system. Although this study found that ease of learning has no significant effect on satisfaction, when three aspects (usefulness, ease of use, and ease of learning) are simultaneously analyzed through F test investigation, they could influence satisfaction.

7. Implication and future works

It is inevitable to provide e-learning with the ability to adapt to diverse student preferences since each student has a specific style in absorbing knowledge. It is also essential to put high effort in the implementation of e-learning, specifically in providing more comprehensive material with a sufficient amount of visually based content, such as pictures, videos, and creative games. Additionally, a fresh and attractive user interface may lead users to utilize the e-learning conveniently. A stable internet connection is also one of the primary issues that should be considered when implementing e learning. With regard to these suggestions, it can provide meaningful feedback for improvement in further research.

Although the research results appear promising in principle, there are still some limitations. The sample includes students from only one department in one school with specific characteristics. Though the number of participants was adequate, a more extensive range of users may provide more significant, valid, and reliable results. Therefore, further investigations should consider different departments and educational institutions. The current study analyzed the usability from the student viewpoint only. In future work, a heuristic evaluation by involving related experts in the aspects of subject matter, pedagogy, multimedia design, software engineering, and so on may contribute to the analysis from a broader perspective.

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