Research Article

Online Learning Quality Measurement Application for Higher Education: Development and Analysis Using ISO 9126

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Abstract.

This study aims to develop an application for measuring the quality of online learning in higher education using the analytical hierarchy process (AHP) model and analyze the quality of the application using the ISO 9126 standard. This is a Research and Development study. The application development process uses the software development life cycle (SDLC) method with the waterfall method. Furthermore, the application quality analysis process uses the ISO 9126 standard, consisting of functionality, reliability, efficiency, maintainability, usability, and portability. The results showed that the application for measuring the quality of higher education online learning based on the AHP model had been successfully developed using the SDLC method with the waterfall model. Furthermore, the results of the analysis of application quality using the ISO 9126 standard show that the average results are excellent and suitable for assessing the quality of online learning in higher education.

Keywords: online learning, higher education, analytical hierarchy process (AHP), ISO 9126

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1. Introduction

Online learning or better known as e-learning, is overgrowing lately. Even in Indonesia, one of the indicators for the assessment of universities is how many courses are held online. There are two e-learning models, namely blended learning and fully online learning. Blended learning combines face-to-face learning and online learning, with a composition of 70% and 30%. E-learning has a high contribution to the development of learning. E-learning provides convenience and becomes an alternative to make learning more interesting [1]. With online learning, students who are located far from campus can access learning anytime and from anywhere. Then with online learning, students from various countries can take courses according to their choice [2]; [3]. Further research [4]

online learning can foster motivation, self-regulation and student retention. Furthermore, students' ICT skills increase when learning is carried out using computer media [5].

Along with the development of online learning, especially in universities, online learning has been carefully conceptualized. One of them must pay attention to the main components contained in e-learning. According to Subandono [6], in general, there are three main components in compiling online learning, namely (1) online learning infrastructure, which can be in the form of personal computers (PCs), network computers and multimedia equipment; (2) online learning system, in the form of class management, material or content creation, discussion forum, assessment system (report), online exam system and all features related to teaching and learning process management; and (3) online learning content. Suryanti et al. [7] have explored student perceptions of online learning readiness. Research findings can be considered for higher education institutions in developing online learning. Later in the same year, the readiness of online teaching by teachers have been explored [8]. The findings from this study are that teachers firmly believe that the ability to TPK (technology, pedagogy knowledge) is crucial to have, but they are a little less confident in providing an online learning environment that allows students to build new knowledge and skills. Thus, this shows the need for evaluation to measure the quality of online learning that has been carried out by teachers, considering what they consider necessary is different from confidence in the success of what they consider essential in online learning.

Governments and universities use various approaches in measuring the quality of online learning, including internal and external reviews using specific assessment standards, reviewing inputs and outputs through quality assurance activities [9]. In addition, other approaches that have been developed to evaluate the quality of online learning include surveys, checklists, observations, peer reviews and expert reviews, with one common way being through Quality Rubrics [10]; [11]; [12]; [13]. An example is QM (Quality Matters rubric), which consists of eight dimensions: learning objectives, teaching materials, learner support, accessibility, assessment, etc. [14].

Empirical studies [11]; [15]; [16]; [17]; [18], that subjects with high-quality scores produce higher learning outcomes (in terms of student performance and satisfaction dimensions). , then Courses with low-quality scores. Although other studies have also shown that not all scores in the quality rubric dimension significantly predict learning outcomes [11]; [15]; [17], exploring the relationship between rubric scores from 23 subjects and final grades of students at two universities in the US, of the four dimensions in the quality rubric,

only the interpersonal interaction dimension was significant and had a positive effect on the final grades of students. This shows that measuring the quality of online learning is not an easy thing. The measurement of the quality of online learning that already exists is mainly using rubrics; measurement tools or software is still minimal.

The limited application software that can assist in measuring the quality of online learning, especially in higher education institutions, is a challenge for university administrators. In developing application software, a method is needed according to the problem to be solved by an online learning provider college. AHP is used to solve a complex unstructured situation [19] into several components in a hierarchical order by assigning subjective values to the relative importance of each variable and assigning the variable that has the highest priority to affect the outcome of the situation. This decision support model will describe a complex multifactor or multi-criteria problem into a hierarchy. The results of the AHP will give weight to the aspects of the assessment that have been determined previously. Therefore, the AHP method can be used as an assessment method in university online learning quality measurement applications.

The quality of software applications can be used as a reference in making products and can be measured by the people who use them. Software quality fulfils explicitly documented functional and performance requirements, explicitly documented development of standards, and implicit properties expected of a professionally built software [20]. Thus, the software is said to be qualified if it meets three main requirements. The main provisions are the fulfilment of user needs, software development standards, and the fulfilment of several implicit criteria. This means that if one of these conditions cannot be met, then the software in question cannot be said to have good quality.

In its development, many models can be used to measure software quality. One of these measurement models is ISO 9126. According [21], ISO characteristics combine several existing quality standards. This standard was developed to identify several aspects of the application to determine compliance with software quality rules. With these measurements, the application made can be a quality application. So the research questions to be answered in this study are:

1. (a) What are the results of developing an online learning quality measurement application for AHP-based universities?

   (b) How is the quality of the resulting application based on the ISO 9126 standard?

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2. Methods

This study uses a Research and Development (R&D) approach. The development method used in the application development process is the Software Development Life Cycle (SDLC) method with the Waterfall model. In this case, product quality analysis, the online learning quality measurement application for higher education institutions, uses the ISO 9126 standard.

This research was conducted at the Muhammadiyah University of Gresik, Indonesia. The sample used was obtained by using the purposive sampling technique. In the development process, the sample consists of (1) black-box testing respondents; (2) respondents were testing aspects of functionality, and (3) respondents testing usability aspects—respondents in black-box testing as many as four people, consisting of teaching experts and linguists. Respondents in testing the functionality aspect were ten respondents consisting of software development experts. Then in testing the usability aspect, determining the number of samples using the standard from Jacob Nielsen with a minimum sample of 20 respondents [22]. Therefore, the sample used in testing the usability aspect was 30 respondents consisting of lecturers, and students at the University of Muhammadiyah Gresik.

The development procedure is carried out using the SDLC method with the Waterfall model, which refers to software engineering. The procedure is carried out in five stages, namely (1) data analysis; (2) system design; (3) implementation of design and coding; (4) system testing; and (5) treatment. Meanwhile, testing the quality of software applications using the ISO 9126 standard consists of functionality, reliability, efficiency, maintainability, usability, and portability.

The instruments used consisted of documentation data, interviews, observations, and application requirements questionnaires at the development stage. The application quality testing instrument used refers to software quality according to ISO 9126, which consists of (1) functional aspect instruments, using a checklist consisting of procedures for running applications that have been made; (2) instrument reliability aspect, using software tools from Load-Impact and WAPT 8.1; (3) efficiency aspect instrument, using software tools from Yslow and PageSpeed Insights; (4) maintainability aspect instrument, using PhpMetrics tools to calculate maintainability index; (5) usability aspect instrument, using a questionnaire with the USE Questionnaire model by Lund [23] which consists of

the criteria of usefulness, ease of use, ease of learning, and satisfaction; and (6) portability aspect instruments using desktop-based web browser tools and mobile-based web browsers. In contrast, the data collection techniques used several techniques, including literature studies, observation, and questionnaires.

Data analysis in the development process is carried out by analyzing application development needs based on functional requirements, requirements for features, and hardware and software requirements. The results of the analysis of the data obtained will be the basis for designing and making online learning quality measurement applications.

Data analysis on the functionality aspect was carried out using descriptive analysis techniques, namely analyzing the percentage of test results for each function carried out by experts. The following calculation obtains the percentage:

$$eligibility\ percentage\ = \frac{observed\ score}{expected\ score} \times 100\%$$

The percentage obtained is then adjusted to the conversion table by referring to the value conversion reference (Bloom, Madaus, & Hasting, 1981) according to Table 1

TABLE 1: Value Conversion Scale.

Achievement percentage	Interpretation
$x \geq 90$	Very good
$80 \leq x < 90$	Good
$70 \leq x < 80$	Enough
$60 \leq x < 70$	Not enough
$x < 60$	Very less

Reliability aspect analysis is done by testing using tools from LoadImpact and WAPT 8.1. The test results using this tool will produce success rate and failure rate values. The success rate was then analyzed using a descriptive analysis technique adapted to Telcordia standards from the percentage of feasibility obtained. The application has passed the test on the reliability aspect if at least 95% of the application can run well when tested for stress testing using WAPT [24].

Efficiency aspect analysis is carried out by looking at the test results on the size of the document data bytes, the number of HTTP requests, minification, GZIP compression, time behaviour and the final score or grade. The testing process is carried out with the help of several tools. The tools used in the test are YSlow and PageSpeed Insight. The results of the tools assessment are then adjusted to the conversion table guided by the value conversion reference as in the functionality aspect.

The maintainability aspect analysis is done by measuring the application source code's maintainability index (MI). The MI results obtained are then converted to a maintainability value scale. Coleman, Ash, Lowther, and Oman [25] stated that "All components above the 85 maintainability index are highly maintainable, components between 85 and 65 are moderately maintainable, and components below 65 are difficult to maintain". It means that the value of 65 is the minimum MI value so that the software is not difficult to maintain.

The usability aspect analysis was carried out using the Cronbach alpha consistency formula. The resulting consistency value is compared with the table of Cronbach's alpha consistency values [26] as in Table 2.

TABLE 2: Value of Cronbach's alpha consistency.

Alpha Cronbach	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.8 \leq \alpha < 0.9$	Good
$0.7 \leq \alpha < 0.8$	Acceptance
$0.6 \leq \alpha < 0.7$	Questionable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

Portability aspect analysis is done by accessing the application using a web browser with several browser software. The application must be tested to be accessible with seven different browsers. If the application can be accessed and runs well on all of this browser software, then the application meets the portability quality aspect.

3. Result and Discussion

3.1. Development of online learning quality measurement applications for higher education based on AHP

Need analysis result

Analysis of application development needs that have been carried out consists of an analysis of functional requirements, requirements for features and requirements for hardware and software. Functional requirements analysis was obtained by conducting observations and interviews. From the results of these observations and interviews, the functional requirements needed are: 1) an application is needed to evaluate the quality of online learning, given a large number of courses; 2) the application is developed based

on online learning standards that the university has determined with a combination of QM rubrics that are used as international standards; 3) the developed application can be accessed anywhere (connected to the internet); 4) the output generated from the application can provide complex information in measuring the quality of online learning.

Furthermore, the needs analysis of the features is developed based on the functional requirements that have been defined. From the analysis of functional requirements, it is found that the requirements for features developed in the application are as follows: 1) users in the application are divided into three namely admins, assessors and elements of higher education leaders; 2) the standard used as a reference in determining the feasibility of the application is ISO 9126; 3) the developed application can give weighting to each category following predetermined standards; 4) the weighting can be done by the assessment team which will then be aggregated; 5) applications can assess the quality of online learning and can provide recommendations directly as input for online learning improvements; 6) the developed application can be accessed easily via desktop and mobile browsers.

Furthermore, the analysis of the need for hardware and software in application development is obtained as follows: 1) hardware requirements: the required device should be connected to the internet, it can be a desktop, laptop or tablet; 2) software requirements: the required software is a web browser, server (domain and hosting) for website configuration and database server.

System design

The system design process in the application includes UML design (modelling language design), interface design, system design and database design. The UML created at the design stage consists of use case, activity, and sequence diagrams. The use case diagram design is presented in Figure 1 below:

Furthermore, the resulting interface design consists of 22-page designs, consisting of pages for admins, assessors, and college administrators.

System implementation and coding

The design implementation phase is carried out based on the page design reference that has been generated previously. For example, the user interface display in the college online learning measurement application consists of 22-page designs, consisting of a page for admin, a page for assessors and a page for college administrators. The results of the implementation in the form of the user interface display will later be used to measure the quality of e-learning.
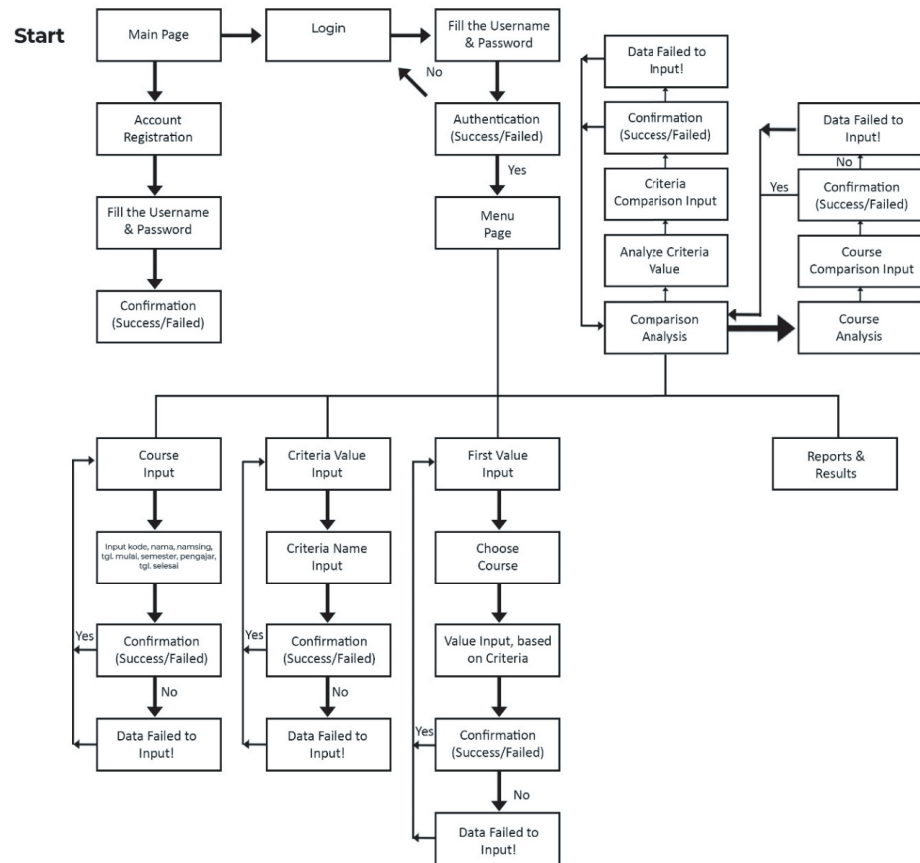
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Figure 1: Use case diagram.

The process of implementing the coding of the e-learning quality measurement application developed using the Sublime Text 2 code editor tools and the Laravel framework in the application of coding. The Laravel framework in the coding process uses a pattern system consisting of three components: the model, view, and controller, also known as MVC. The results of the coding implementation, the coding workflow process starts from the model components that play a role in data acquisition. Then the view component plays a role in displaying data that has been previously processed in the system. Finally, the controller component plays a role in processing data that has been processed by the model component and then forwarded to the view component to see the desired data output in the application.

From the database implementation phase, it was found that the database created was using the MySQL database. The previously designed tables are configured to assist developers in determining the relationship between tables in the database. The database tables configured at this stage are 13 tables according to the previous

database design. The database management process is carried out using the PHP-MyAdmin application.

System testing

The system testing process is carried out to produce application products under the specifications in the needs analysis. Therefore, system testing on applications with the SDLC standard is better known as black-box testing. Blackbox testing is carried out by testing instrument validation and application validation.

The instrument validation that has been carried out is used to obtain instruments that follow the purpose of application development. The instrument components that were validated were the language suitability component, the questionnaire instrument, and the SDLC standard implementation used in the application. In addition, experts validate instruments under their field of competence. Based on the results of consultation and validation carried out by experts, several aspects that need to be improved are vocabulary and sentence structure to match the rules of the desired target language.

Application validation that has been carried out is used to produce applications under application development goals. Some of the validated application components include the user interface, user experience, system functions, system processes, and the standard framework used in the application. In addition, experts validate applications according to their areas of competence. Based on the results of consultation and validation carried out by experts, several aspects that need to be improved are (1) the addition of successful notifications; (2) changes to data by experts in the weighting process; (3) alternative answers in the expert weighting process are adjusted to the standard; and (4) higher education managers can see the average assessment results of all respondents.

3.2. Application quality analysis based on ISO 9126 Standard

Testing aspects of functionality

Testing the functionality aspect is done by using a checklist sheet conducted by five experts. The experts involved in the testing consisted of lecturers and IT practitioners. Based on the results of testing the quality of applications developed on functionality, the online learning quality measurement application for universities has a success of 99.5%. From the value obtained, the resulting application is in the excellent category, so that the application that has been developed has met the functionality aspect.

Testing the reliability aspect

Application testing on the reliability aspect is carried out with the help of load impact and WAPT 8.1 tools. The simulation results show that every time there is an additional user, there is no significant change to the LoadTime. Furthermore, the stress testing simulation results found that the process was running successfully without any failures from 90-91 trials. This shows that from the aspect of reliability, the online learning measurement application for universities has a 100% reliable percentage or is in the excellent reliability category.

Testing the second reliability aspect using the WAPT 8.1 tool, which is used to see stress testing of the developed application, is briefly presented in Table 3.

TABLE 3: Results of stress testing WAPT 8.1.

Metric	Success	Fail	Percentage	Result
Sessions	90	1	98,9%	Very high
Pages	89	2	97,8%	Very high
Hits	1147	1	99,9%	Very high

The tests in Table 3 have an average test value of 98.8%, so it can be concluded that the developed application has an excellent reliability quality scale.

Testing of Efficiency aspect

Application testing on the efficiency aspect is carried out to see the level of performance efficiency of the developed application. The testing process is carried out with the PageSpeed Insight tool. Based on the test results of the developed application, the percentage of success is 81.8%, or in the excellent category.

Testing aspects of maintainability

Application testing on the maintainability aspect is done by looking for the Maintainability index (MI) value. MI is obtained by analyzing the application source code using Phpmetrics tools. Phpmetrics calculation results in the resulting MI value is 110.24. The value obtained shows that the quality of the application in the maintainability aspect is in the excellent category.

Testing usability aspects

Application testing on usability uses a questionnaire instrument adopted from Arnold, namely the USE Questionnaire, which consists of 30 questions with alternative answers according to a Likert scale of 1-5. The questionnaire was distributed to 25 respondents, consisting of 10 lecturers of Informatics Engineering, 10

Lecturers who teach courses, five elements of higher education management. The results of the usability assessment by the respondents were then calculated for the consistency value using SPSS 22.0. The results of the calculation of the Cronbach alpha coefficient are presented in Table 4

TABLE 4: Results of the Cronbach alpha coefficient.

Cronbach alpha	N of items
0.950	25

Based on Table 4, Cronbach's alpha value is 0.950, then this value is adjusted to the Cronbach's alpha consistency table and shows an excellent or outstanding value.

Next is to calculate the percentage value of the usability aspect assessment by dividing the total score by the maximum score and then multiplying by 100%. Thus, the percentage of usability aspects obtained is 78% or in the decent category.

Testing portability aspects

Testing on the portability aspect is done by testing in accessing the application on several different web browsers. The web browsers used are desktop and mobile-based. Testing on the portability aspect uses five desktop-based web browsers (Mozilla Firefox, Google Chrome, Opera, Safari, IE) and six mobile-based web browsers (Firefox Mobile, Opera Mini, Dolphin, UC Browser, Chrome Mobile, Mobile Web Browser). The test results on the portability aspect can be seen in Table 5.

TABLE 5: Portability test results.

No	Browser name	Result
	Desktop Browser	
1	Mozilla Firefox	Success
2	Google Chrome	Success
3	Safari Browser	Success
4	Internet Explorer	Success
5	Opera Browser	Success
	Mobile Browser	
6	Firefox Mobile	Success
7	Opera mini	Success
8	Dolphin	Success
9	UC Browser	Success
10	Chrome Mobile	Success
11	Web Browser Mobile	Success

After conducting the test, it was found that the e-learning system assessment application was running well without any errors. Therefore, it can be concluded that the developed application has met the portability aspect with an outstanding category.

4. Conclusions

The results show that the online learning quality measurement application for universities has been successfully developed using the waterfall model SDLC method with aspects of assessment based on the ISO 9126 standard using the Analytical Hierarchy Process (AHP) technique used to evaluate the quality of online learning in universities. Furthermore, the results of the analysis of the quality of the application using the ISO 9126 standard are as follows: (1) the functionality aspect is scored 99.5% or very good; (2) the reliability aspect obtained values of 100% and 98.8% or very good; (3) the efficiency aspect is 81.8% or good; (4) the maintainability aspect obtained a value of 110.24 or very good; (5) the usability aspect obtained a value of 78% and 0.95 or very good; and (6) the portability aspect is obtained without any errors.

Acknowledgements

References

[1] Rennie F, Morrison T. *E-learning and social networking handbook: Resources for higher education*. 2013.

[2] Baker SC, Wentz RK, Woods MM. Using virtual worlds in education: Second Life® as an educational tool. *Teach Psychol*. 2009;36(1):59–64.

[3] Baker SC, Wentz RK, Woods MM. Using virtual worlds in education: Second life® as an educational tool. *Teach Psychol*. 2009;36(1):59–64.

[4] Fisher M, Baird DE. 2005 Online learning design that fosters student support, self⊠regulation, and retention. *Campus-wide Inf Syst*.

2005. https://doi.org/10.1108/10650740510587100

[5] Robinson CC, Hullinger H. New benchmarks in higher education: Student engagement in online learning. *J Educ Bus*. 2008;84(2):101–108.

[6] Subandowo M. *The use of e-learning in increasing learning productivity.* 2016.

[7] Suryanti S, Sutaji D, Iswanti. Perception of readiness for online learning: Voice from Mathematics Learners. *J Phys Conf Ser*. 2021;1940(1):012103.

[8] [8] Ser. 2021;1933:012117.

[9] Robinson B. Governance, accreditation and quality assurance in open and distance education. In: *Policy for open and distance learning*. Routledge; 2003. pp. 197–222.

[10] Custard M, Sumner T. Using machine learning to support quality judgments. *Dlib Mag*. 2005;11(10):11.

[11] Jaggars SS, Xu D. How do online course design features influence student performance? *Comput Educ*. 2016;95:270–284.

[12] Roblyer M, Wiencke W. Design and use of a rubric to assess and encourage interactive qualities in distance courses. *Am J Dist Educ*. 2003;17(2):77–98.

[13] Yuan M, Recker M. Does audience matter? Comparing teachers' and non-teachers' application and perception of quality rubrics for evaluating open educational resources. *Educ Technol Res Dev*. 2019;67(1):39–61.

[14] Matters Q. Quality matters higher education rubric. 2018.

[15] Lee Y, Choi J. A review of online course dropout research: Implications for practice and future research. *Educ Technol Res Dev*. 2011;59(5):593–618.

[16] Liu IF, Chen MC, Sun YS, Wible D, Kuo CH. Extending the TAM model to explore the factors that affect intention to use an online learning community. *Comput Educ*. 2010;54(2):600–610.

[17] Sun PC, Tsai RJ, Finger G, Chen YY, Yeh D. What drives a successful e- Learning? An empirical investigation of the critical factors influencing learner satisfaction. *Comput Educ*. 2008;50(4):1183–1202.

[18] Swan K, Matthews D, Bogle L, Boles E, Day S. Linking online course design and implementation to learning outcomes: A design experiment. *Internet High Educ*. 2012;15(2):81–88.

[19] Vach T, Mašín I. AHP-based evaluation of vertical gardens design *current methods of construction design*. Cham: Springer; 2020. pp. 415–421.

[20] Dunn MF, Knight JC. Software reuse in an industrial setting: A case study *Proceedings-13th International Conference on Software Engineering (pp. 329-330). IEEE Computer Society.* 1991. https://doi.org/10.1109/ICSE.1991.130659.

[21] Fahmy S, Haslinda N, Roslina W, Fariha Z. Evaluating the quality of software in e-book using the ISO 9126 model. *Int J Control Autom*. 2012;5:115–122.

[22] Nielsen J, Phillips VL. Estimating the relative usability of two interfaces: Heuristic, formal, and empirical methods compared *Proceedings of the INTERACT'93 and CHI'93 conference on Human Factors in Computing Systems*. pp 214–221.

[23] Lund A. Measuring usability with the USE Questionnaire. 2001.

[24] Asthana A, Olivieri J. Quantifying software reliability and readliness. *IEEE*; 2009.

[25] Coleman D, Ash D, Lowther B, Oman P. Using metrics to evaluate software system maintainability. *Computer*. 1994;27(8):44–49.

[26] Gilem J, Gilem R. Calculating, interpreting, and reporting Cronbach's Alpha reliability, coeficient for Liker-Type scales. Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education; 2003.