TECHNISCHE UNIVERSITÄT DRESDEN

An Adaptive E-Learning System based on Student's Learning Styles and Knowledge Level

Dissertation

submitted to the Faculty of Education,
Technische Universität Dresden
for the degree of
Doctor of Philosophy (Dr. phil.)

By

Didik Hariyanto

born on May 2nd, 1977 in Surabaya, Indonesia

Supervisor

Prof. Dr. Thomas Köhler

Chair of Educational Technology,
Faculty of Education, Technische Universität Dresden

Defense Committee

Prof. Dr. Martin Hartmann (TU Dresden)
Prof. Dr. Thomas Köhler (TU Dresden)
Prof. Dr. Bruri Triyono (UNY)
Prof. Dr. Stephan Abele (TU Dresden)
Dr. Wendkouni J. Eric Sawadogo (TU Dresden)

Day of submission: 11.11.2019
Day of the defense: 19.06.2020

ABSTRACT

There is a strong demand for a positive instructional application in order to address the strategic plan of the Ministry of Education and Culture in Indonesia to change the ratio of vocational secondary school to be higher than the general school one. The immense growth of information and communication technology may be possible to provide a computer-based personalized e-learning system to the learners in order to overcome the fact that each student has their own preferences in learning. This study offers an adaptive e-learning system by considering two sources of personalization: the student's learning style and initial knowledge. In order to investigate the effectiveness of the proposed e-learning program, the students' achievement in terms of three lowest levels in the cognitive domain (knowledge, comprehension, and application) in the e-learning group is compared with the traditional classroom group. Another area that is interesting to explore is the usability evaluation based on the students' perspective and the relationship between aspects specified in the usability questionnaire.

The design and development process of the adaptive e-learning system in this study was considering both the instructional system design and software engineering. The first phase was started by analyzing the participants' candidate, the subject course, and the online delivery medium. The next step was designing the procedure, the adaptation set of rules, and the user interface. Then, the process to develop the instructional system based on the data collected from the previous phases was conducted. The next stage was implemented the instructional program to the students in a small group setting. Finally, the e-learning application was evaluated in three different settings: functional-based testing, experts-based assessment, and user-perspective evaluation.

The next action is an experimental study by applying the adaptive e-learning system to the learning process. There were two groups involved in this experiment. The experimental group that consisted of 21 students who learned the Digital Simulation course by utilizing the adaptive e-learning system. Another group was the control group that included 21 students who studied the same course through the traditional classroom setting. There were two instruments used to collect the required data. The first instrument contained 30 multiple-choice questions that considered the cognitive levels of knowledge,

comprehension, and application. This instrument was used to assess the student achievement of the intended course. The second instrument was the usability questionnaire that consisted of 30 4-point Likert scale statements. This questionnaire was composed of four dimensions, namely usefulness, ease of use, ease of learning, and satisfaction. This questionnaire aimed to evaluate the usability of the adaptive e-learning application based on the student's perspective.

The finding in this study revealed an unusual phenomenon which the pre-test result of the control group was significantly exceeding those of the experimental group. For the post-test score comparison, although there was a higher achievement in the e-learning group than in the regular group, the difference between both achievements was not statistically significant. The comparison in terms of the gain score was conducted in order to investigate which treatment group was more effective. The results indicated that the total gain score achieved by the experimental group was significantly higher than those recorded by the control group. This evidence was also valid with regard to the knowledge, comprehension, and application-level of the cognitive domain. These findings confirmed that the group who utilized the adaptive e-learning system was reported more effective in terms of the achievement score than the group of students who studied in the traditional setting. Another important finding was related to usability evaluation. The measurement score was analyzed through different approaches and revealed that the usability score categorized in the acceptable criteria in all aspects (usefulness, ease of use, ease of learning, and satisfaction). Furthermore, the regression analysis was conducted in order to explore the relation between the variables. The first finding reported that the independent variables (usefulness, ease of use, and ease of learning) simultaneously influenced the dependent variable (satisfaction). In the meantime, the partial t-Test found varying results. The results indicated that the variable ease of use was significantly influenced variable satisfaction. Meanwhile, variable usefulness and ease of learning were not significantly affected variable satisfaction.

Keywords: adaptive e-learning system, learning style, initial knowledge, usability evaluation, vocational education.

ZUSAMMENFASSUNG

Es besteht eine starke Nachfrage nach einer positiven Applikation zum Lernen, um den strategischen Plan des indonesischen Ministeriums für Bildung und Kultur zu fördern, dass die Ratio von Berufsschule höher als die allgemeinbildende Schule werden kann. Die rasante entwicklung der Informations- und Kommunikationstechnologie könnte es ermöglichen, den Lernenden ein computergestütztes, personalisiertes E-Learning-System zur Verfügung zu stellen, um die Tatsache zu überwinden, dass jeder Lernende seine eigene Präferenz hat. Diese Studie bietet ein adaptives E-Learning-System, bei dem zwei Quellen der Personalisierung berücksichtigt werden: der Lernstil des Schülers und das Vorwissen. Um die Wirksamkeit des vorgeschlagenen E-Learning-Programms zu untersuchen, werden die Leistungen der Schüler bezüglich der drei niedrigsten Ebenen im kognitiven Bereich (Wissen, Verständnis und Anwendung) in der E-Learning-Gruppe mit denen der traditionellen Unterrichtsgruppe verglichen. Ein weiterer interessanter Bereich ist die sogannte schülerperspektive Usability-Bewertung und die Beziehung zwischen den Usability-Fragebogen angegebenen Aspekten zu erforschen.

Der Entwurfs- und Entwicklungsprozess des adaptiven E-Learning-Systems in dieser Studie berücksichtigte sowohl das Instruktionsdesign als auch das Software-Engineering. Die erste Phase begann mit der Analyse des Kandidaten der Teilnehmer, des Fachkurses und des Online-Liefermediums. Der nächste Schritt bestand darin, die Prozedur, die Regelwerk der Adaptation und die Benutzeroberfläche zu entwerfen. Dann wurde Entwicklungsprozess des Lehrsystems auf der Grundlage der aus den vorherigen Phasen gesammelten Daten durchgeführt. Die nächste Phase war die Implementierung des Unterrichtsprogramms für die Schüler in einer kleinen Gruppe. Schließlich wurde die E-Learning-Anwendung in drei verschiedenen Teststrategien bewertet: Funktionsbasiertes Testen, Expertenbasierte Bewertung und benutzerperspektivische Bewertung.

Die nächste Aktion ist eine experimentelle Studie, bei der das adaptive E-Learning-System im Lernprozess angewendet wird. An diesem Experiment waren zwei Gruppen beteiligt. Die Experimentalgruppe bestand aus 21 Studenten, die den Unterrichtsfach Digital Simulation mithilfe des adaptiven E-Learning-Systems lernten. Eine andere Gruppe war die Kontrollgruppe, die 21 Schüler umfasste, die dasselbe Unterrichtsfach in der traditionellen

Klasse lernten. Es wurden zwei Instrumente verwendet, um die erforderlichen Daten zu erheben. Das erste Instrument bestand aus 30 Multiple-Choice-Fragen, die die kognitiven Ebenen von Wissen, Verstehen und Anwendung enthielten. Dieses Instrument wurde verwendet, um die Schülerleistung bei dem obengeschriebenen Unterrichtsfach zu bewerten. Das zweite Instrument war der Usability-Fragebogen, der aus 30 4-Punkte-Likert Aussagen bestand. Dieser Fragebogen bestand aus vier Dimensionen nämlich Nützlichkeit, Benutzerfreundlichkeit, Lernfreundlichkeit und Zufriedenheit. Mit diesem Fragebogen wurde die Usability der adaptiven E-Learning-Applikation basierend auf die Perspektive des Schülers bewertet.

Der Befund dieser Studie ergab ein ungewöhnliches Phänomen, bei dem das Ergebnis des Pre-Tests der Kontrollgruppe signifikant höher als Experimentalgruppe. Zum Post-Test Vergleich, obwohl die Leistung der E-Learning Gruppe höher als der von der regulären war, war der Unterschied zwischen den beiden statistisch nicht signifikant. Der Vergleich der Punktzahlsteigerung wurde gemacht, um zu untersuchen, welche Behandlungsgruppe effektiver war. Die Ergebnisse zeigten, dass die gesamte Punktzahlsteigerung von der Experimentalgruppe signifikant höher als die von der Kontrollgruppe war. Diese Beweise waren auch im Hinblick auf das Wissen, das Verständnis und die Anwendungsebene des kognitiven Bereichs gültig. Diese Ergebnisse bestätigten, dass die Gruppe des adaptiven E-Learning-Systems bezüglich ihrer Leistung effektiver war als die Gruppe der Studenten, die in der traditionellen Klasse lernten. Ein weiterer wichtiger Befund betraf die Bewertung der Usability. Die Punktzahl der Messung wurde anhand verschiedener Ansätze analysiert und ergab, dass der Usability-Score in allen Aspekten (Nützlichkeit, Benutzerfreundlichkeit, Lernfreundlichkeit und Zufriedenheit) den akzeptablen Kriterien zuzuordnen ist. Darüber hinaus wurde die Regressionsanalyse durchgeführt, um die Beziehung zwischen den Variablen zu untersuchen. Der erste Befund ergab, dass die unabhängigen Variablen (Nützlichkeit, Benutzerfreundlichkeit und Lernfreundlichkeit) gleichzeitig die abhängige Variable (Zufriedenheit) beeinflussten. In der Zwischenzeit ergab der Teil t-Test unterschiedliche Ergebnisse. Die Ergebnisse zeigten, dass die variable Benutzerfreundlichkeit die variable Zufriedenheit signifikant beeinflusste. Der variable Nützlichkeit und die Lernfreundlichkeit wirkten sich indessen nicht signifikant auf die variable Zufriedenheit aus.

Stichwörter: Adaptives E-Learning-System, Lernstil, Vorwissen, Usability-Evaluation, berufliche Bildung.

ACKNOWLEDGMENTS

First of all, I would like to say *Alhamdulillahi rabbil 'alamin*, thanks to the Almighty God, Allah SWT for always giving me his blessing in the challenging journey of my Doctoral. Secondly, may peace be upon the prophet Muhammad SAW who has guided us in this transitory life.

I would like to express my very great appreciation to my advisor Prof. Dr. Thomas Köhler for his patient support, professional guidance, valuable and constructive suggestions during this research work.

In the very beginning step of my Doctoral application, I was struggling hard in the scholarship process, on this occasion I would like to express my sincere gratitude to Prof. Dr. Bruri Triyono for his full support and enthusiastic encouragement. I would also like to extend my gratitude to all my colleagues in general at Yogyakarta State University and in particular at the Electrical Engineering Department in Karangmalang.

I am grateful to the academic staff of the Institute of Vocational Education and Vocational Didactics in Weberplatz, especially for Frau Sabine Schmidt and Frau Kerstin Liebscher who have been helped me a lot in the administration things. I am also grateful to all fellow doctoral students Aline Bergert, Christiane Bergner, Ingrid Lugo, Liu Huan, Manuela Heindl, Mattis Altmann, Peter Döppler, Silvia Blass, Sun Ying, Thomas Schöftner, Yanning Lu for their kindness, help, and friendship.

My grateful are also extended to the supervising team at the doctoral colloquium Dr. Claudia Börner, Dr. Jörg Neumann, Dr. Sander Münster, and Prof. Dr. Eric Schoop for their advice and feedback at various research stages presented. Special thanks to Prof. Dr. Daniel Apollon from the Digital Culture Research Group, University of Bergen, Norway for plenty of questions and fruitful discussion during my presentation in 2018 Summer School at Bergen.

Thanks to the proofreader team, Ubed Sonai Fahrudin Arrozi who is also my apartment-mate, Yanuar Dwi Putra Limasale, and Satyadharma Tirtarasa for your hard work to check the readibility and grammar in my dissertation. Special thanks to Rita Fransina Maruanaya for the careful translation to Deutsch for the 'zusammenfassung' section.

Living far away from home and family gives me a special value to friendship and brotherhood. Thanks to all members of Wohnzimmer club, Genk Sirkus, Yasinan group, and Forum Masyarakat Indonesia di Dresden (FORMID) for giving me a warm and close relationship like my own family.

I would also like to acknowledge the IGSP-DAAD (Indonesian Germany Scholarship Program - Deutscher Akademischer Austausch Dienst) for supporting me with the scholarship during my doctoral research in Germany.

To be abroad for pursuing my Doctoral is my biggest dream; it would have been impossible without invaluable and continuous support from my beloved family. And finally, last but definitely not least, I would like to acknowledge my dear wife Budi Lestari for her unconditional love and never-ending prayers; and my sweet daughters Regita Lestariyan Lainy and Shafadel Lestariyan Lainy for your cheerful motivation. Thank you for your great patience in our long-distance family life.

DEDICATION

I dedicate this Ph.D. thesis to my beloved family, my wife (*Budi Lestari*) and my daughters (*Regita* and *Shafadel*), who had to be miles away for long periods from their loved one. Thanks for all your endless love and patience until this Ph.D. endeavor reaches the last line.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AC	Abstract Conceptualization
ADDIC	Analyze, Design, Develop, Implement, and Control
ADDIE	Analysis, Design, Development, Implementation, and Evaluation
AE	Active Experimentation
AHAM	Adaptive Hypermedia Application Model
AI	Artificial Intelligence
AK	Akademi Komunitas
ANOVA	Analysis of Variance
APJII	Asosiasi Penyelenggara Jasa Internet Indonesia
Bappeda	Badan Perencanaan dan Pembangunan Daerah
BLK	Balai Latihan Kerja
CAT	Category
CD-ROM	Compact Disc Read-Only Memory
CE	Concrete Experience
CI	Code Igniter
CSUQ	Computer System Usability Questionnaire
df	Degree of Freedom
DGHE	Directorate-General for Higher Education
ES	Effect Size
FSLSM	Felder-Silverman Learning Style Model
GRSLSS	Grasha-Riechmann Student Learning Style Scales
GUI	Graphical User Interface
HCI	Human-Computer Interaction
HEI	Higher Education Institution
HTTP	Hypertext Transfer Protocol
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ILS	Index of Learning Style
IPISD	Interservice Procedures for Instructional Systems Development

ISD	Instructional System Design
ISO	International Organization for Standardization
ITS	Intelligent Tutoring Systems
KB	Kelompok Bermain
LMS	Learning Management System
LSI	Learning Style Inventory
LSQ	Learning Style Questionnaire
MA	Madrasah Aliyah
MAK	Madrasah Aliyah Kejuruan
MBTI	Myers-Briggs Type Indicator
MI	Madrasah Ibtidaiyah
MoEC	Ministry of Education and Culture
MoMT	Ministry of Manpower and Transmigration
MoRA	Ministry of Religious Affairs
MoRT	Ministry of Research and Technology
MoRTHE	Ministry of Research, Technology, and Higher Education
MTs	Madrasah Tsanawiyah
MVC	Model View Controller
N-Gain	Normalized Gain
OHP	Over Head Projector
PHP	Personal Home Page
QUIS	Questionnaire for User Interaction and Satisfaction
RO	Reflective Observation
SD	Sekolah Dasar
SMA	Sekolah Menengah Atas
SMK	Sekolah Menengah Kejuruan
SMP	Sekolah Menengah Pertama
SPSS	Statistical Package for the Social Sciences
SQL	Structured Query Language
SSS	Senior Secondary School
SUMI	Software Usability Measurement Inventory
SUS	System Usability Score
TK	Taman Kanak-Kanak

TVET	Technical and Vocational Education and Training
USE	Usefulness, Satisfaction, and Ease of Use
VAK	Visual, Auditory, and Kinesthetic
VARK	Visual, Aural, Read/Write, and Kinesthetic
VIF	Variance Inflation Factor
VSSS	Vocational Senior Secondary School
Wi-Fi	Wireless Fidelity

1

INTRODUCTION TO THE STUDY

1.1. Research Background

Learning is a process of acquiring new, modifying existing, or reinforcing current knowledge from any reputable sources through any communication mediums. In the traditional classroom setting, learning is the process of knowledge transfer from a teacher to the students. The process is usually organized in a classroom by means face-to-face and commonly delivered by oral techniques, note-taking, and using a little technological support. A traditional school typically requires students to attend classes, and there is a fixed amount of time for interaction.

In the information and communication age, the learning process can rely upon a personal computer and Internet connection as a channel. The students do not have to be in the same place and at the same time as the teacher. Nevertheless, the students can acquire knowledge as well as they can be in the traditional classroom. This type of learning is commonly known as e-learning. Clark & Mayer (2016) defined e-learning as an instruction delivered through digital devices using specific modes such as CD-ROM, internet, or intranet. The “e” in the term of “e-learning” refers to how the course is transformed and stored in a digital form and then delivered through electronic modes (Clark & Mayer, 2016). Because of the enormous rise in the number of internet users and network technology, e-learning has become a popular choice amongst internet users. According to Rosenberg & Foshay (2002), e-learning depends on internet technology and is typically a networked form of traditional learning paradigms. E-learning is not limited to a specific time and place as traditional classroom instruction. Users can access the e-learning whenever and wherever they want (Chen & Zhang, 2008). This method may increase the opportunity for people to receive information to a certain extent.

One thing that should be considered in e-learning is an internet connection and its supporting infrastructures. Some studies have reported that internet access is the most challenging concern in online courses specifically in developing countries (Guspatni, 2018; Qureshi, Ilyas, Yasmin, & Whitty, 2012; Stark, Lassiter, & Kuemper, 2013). Low internet bandwidth and network infrastructure problems are often faced by the user in accessing online learning. Instead of using an internet connection to access online learning, the intranet connection provides more reliability in terms of speed and bandwidth. The intranet mechanism can be configured by installing the online course in the server or computer, which acts as a server in the same location as the computer client used by users. This strategy may minimize the challenge of providing satisfactory internet speed.

Indonesia, officially called the Republic of Indonesia, is considered one of the developing countries located in Southeast Asian. Indonesia consists of diverse ethnics and varied local languages, spreading on more than 17 thousand islands (Indonesia, 2017). A census of Indonesia population in 2010 reported that the total Indonesian population is more than 230 million (Badan Pusat Statistik, 2010) and predicted to be roughly 270 million in 2020 (Badan Pusat Statistik, 2013). Concerning to the internet user, the Indonesia internet service provider association surveyed that there is 54.68% of Indonesian people who have accessibility on the internet in 2017 (APJII, 2017). APJII (Asosiasi Penyelenggara Jasa Internet Indonesia) also reported that the penetration of internet use in Indonesia is significantly increased from year to year. Moreover, the published data also evidenced that 16.68% of internet users are at the secondary school age within 13 to 18 years old (APJII, 2017).

With regard to the education sector in Indonesia, both general and vocational schools in Indonesia officially fall under the responsibility of the Ministry of Education and Culture (Kementerian Pendidikan dan Kebudayaan). Whereas the Ministry of Religious Affairs (Kementerian Agama) liable for Islamic-based schools. However, the most responsible minister for education policy, in general, is handled by the Ministry of Education and Culture. Related to the policy for senior secondary school level, the strategic plan from the Ministry of Education and Culture is reversing the ratio of the general senior secondary school to the vocational one from 70:30 in 2004 to 30:70 by 2025 (Departemen Pendidikan Nasional, 2005). It comes from the fact that most of the graduated students from senior secondary level tend to find a job rather than continuing to the university level.

In most provinces in Indonesia, particularly in Yogyakarta province, the majority of junior secondary school graduates prefer continuing their studies at vocational senior secondary schools than at general senior secondary schools. Based on the data collected by Yogyakarta's Institute of Regional Planning and Development (Badan Perencanaan dan Pembangunan Daerah, or Bappeda) from 2012 to 2015, students who graduated from junior secondary school favored continuing their studies at a vocational secondary school (Bappeda DIY, 2015a). Additionally, the number of vocational secondary schools in Yogyakarta Province surpasses the number of general secondary schools (211 compared with 155, respectively) (Bappeda DIY, 2015b).

This strategic plan and the situation in the junior secondary school graduates should be considered as valuable information for the development guidance of the vocational secondary school. To facilitate that, a crucial part of this situation is to provide a suitable method and appropriate learning resources for students. There is a common conception that one student differs from another. Every student has her or his preferred learning type and unique learning style strength (Dunn, 1990). Consequently, the instructor may not provide a specific course through the same strategy to all learners.

It is a general situation where some students opt for information to be presented visually, while others prefer it verbally. Some students would rather process ideas actively than reflectively. Certain students enjoy taking in information by sensing, whereas others prefer by intuiting. Numerous students like sequentially organizing material, yet many others require a global view. Manifold learning styles create a possibility for educators to adopt an inaccurate strategy in the learning and teaching process. Students may reject a learning situation that does not match their learning style, which risks derailing the learning and teaching process. Many theories argue that designing an instructional environment befitting a student's learning style is essential for effective learning. At the beginning of the learning process, teachers should know and underline what their student's learning styles are. If educators could prepare all the materials and methods suitable for student's requirements, then learning and teaching could be run as a well-planned and effective process.

Nowadays, e-learning systems are in use in many schools. The general characteristic of a common e-learning system is provided the same interface for all users. In addition, the material is presented with similar content to all users. However, there are limitations to this

approach. As we can see, each student has his/her learning pace and behavior. Thus, students should be treated as individuals rather than as a homogeneous group in e-learning. To address the problem, a system needs to be considered that can take into account the different student's preferences. Adaptive e-learning helps students to learn according to their learning style and level of ability. Adaptive e-learning will display and navigate material in accordance with the student's learning styles and knowledge level.

An adaptive e-learning system is a type of software system that can provide content to the learner and adjust it to suit the needs of a particular learner based on the learner's characteristics (Jevremović & Vasić, 2010; Shute & Towle, 2003). Since students have many differences, adaptive e-learning is the key to overcoming these differences and making learning suited for all (Melicherikova & Bušíková, 2012). Adaptivity is one of the most important keys in dealing with differences amongst learners. Kareal & Klema (2006) suggested an adaptivity rule as an essential part of an effective educational process and stated that it should be implemented in e-learning systems. Thus, adaptive e-learning has the capability to create a suitable environment and content based on different student's preferences to improve the effectiveness of the learning process.

1.2. Research Questions

The research questions revealed in this study are strongly correlated with the existence of the adaptive e-learning system. At this point, many researchers have studied adaptive e-learning systems based on a single criterion, such as learning style, cognitive style, knowledge state, or student's behavior. However, few studies have considered multiple learning criteria that offer more personalization learning environment. This current study is considered two aspects of personalization: student's learning styles and initial knowledge.

The research starts firstly by designing and developing adaptive e-learning that should consider the pedagogical and technological aspects. Then, the comparison between the group exposed with the adaptive e-learning system and the group conducted traditional learning is studied in order to measure the learning effectiveness. Moreover, student satisfaction related to the utilizing of the adaptive e-learning system in the learning process is an essential factor that should be investigated. Another important aspect is to explore the relationship amongst attributes involved in the usability. Accordingly, there are four main research questions addressed in this study formulated as follows:

1. How are the design and development of the adaptive e-learning system based on student's learning styles and knowledge level?
2. How effective is the adaptive e-learning system when compared with traditional learning?
3. Do the students find the adaptive e-learning system satisfying?
4. To what extent are usefulness, ease of use, and ease of learning influence satisfaction?

1.3. Research Objectives

Given the research questions exposed in this study, the objectives of this study are:

1. To develop a comprehensive adaptive e-learning system based on learning style and initial knowledge of students by considering the pedagogical and technological aspects.
2. To study whether the group of students who experienced the learning process through the adaptive e-learning system has a better learning achievement than those in the traditional group.
3. To investigate student satisfaction for those who used the adaptive e-learning system in the learning process.
4. To explore the relationship amongst variables associated with the usability.

1.4. Research Contributions

Generally, the existence of the adaptive e-learning system designed and developed in this study is the main contribution to knowledge, specifically in the field of educational technology. Although it is common to know that there are many e-learning systems provided either in a freeware or commercial basis, in non-adaptive or adaptive approach. However, there is something different offered by the adaptive e-learning system in this study. One important thing in the e-learning system in this study is considering two variables of adaptation, the first is by taking into account the learning style of learners, and the second is favoring the student's pre-knowledge. Using one criterion for adaptation is much common than multi-criteria. The more criteria used the better personalization provided by the e-learning system that may lead the students more convenient in absorbing information in the learning process. Another essential aspect of this e-learning is considering Bloom's taxonomy in the development of the achievement test. Three cognitive

levels considered in the achievement test can provide a better overview of the student's performance. Given the specification of the e-learning mentioned above, it may use as a reference model for designing a personalized e-learning system. Other related contributions are the findings of this study in terms of the effectiveness of adaptive e-learning and the student's satisfaction can be used as guidance when implemented the e-learning application for different subjects.

1.5. List of Publications

The number of papers as part of this doctoral research were presented in some international peer-reviewed conferences in different countries and published in proceedings. It includes one paper that has been accepted in a good scientifically indexed international journal. These papers are listed below:

- **Hariyanto, D.**, & Köhler, T. A Proposed Architectural Model for an Adaptive E-Learning System Based on Student's Learning Styles and Knowledge Level. This paper has been presented in the International Conference on Teaching and Learning in Education (ICTLE 2016) at Kuala Lumpur, Malaysia, on March, 1st - 2nd 2016 and published in the Proceeding (pp. 18–22).
- **Hariyanto, D.**, & Köhler, T. An Adaptive User Interface for an E-learning System by Accommodating Learning Style and Initial Knowledge. This paper has been presented in the International Conference on Technology and Vocational Teachers (ICTVT 2017) at Yogyakarta, Indonesia, on September, 28th 2017 and published in the Proceeding (https://doi.org/10.2991/ictvt-17.2017.4).
- **Hariyanto, D.**, & Köhler, T. Measuring Knowledge in Computer Network Vocational Training by Monitoring Learning Style Preferences of Students. This paper has been presented in Wissensgemeinschaften in Wirtschaft, Wissenschaft und Offentlicher Verwaltung - 20. Workshop GeNeMe 2017, Gemeinschaften in Neuen Medien at Dresden, Germany, on October, 18th - 20th 2017 and published in the Scopus-indexed Proceeding (Vol. 2017-Octob, pp. 183-195).
- **Hariyanto, D.**, Triyono, M.B., & Köhler, T. Usability Evaluation of Personalized Adaptive E-learning System using USE Questionnaire. This paper has been accepted in the Knowledge Management & E-Learning: An International Journal and will be published in the upcoming issue. This journal is indexed in Scopus and Emerging Sources Citation Index (ESCI).

1.6. Dissertation Structure

This thesis is organized into five chapters. Chapter 1 draws a rationale background of why this research is important to be conducted. Based on that, the research questions are generated as a basis for the researcher to deal with the problem. The research objectives describe as guidance that should be achieved in this study. In this chapter, it is also mentioned several research papers presented in the international conferences in several different countries and published in conference proceedings by the author.

Chapter 2 presents a review of literature related to the research topic. It includes an insight of the Indonesian education system, especially in vocational secondary high school. It also discusses the recent issue that emerged in Indonesian education. Additionally, the main concern related to the e-learning and its adaptivity technology is also described. The variables of adaptivity in this research, i.e., student's learning styles and knowledge state are discussed in more detail in order to support the adaptivity techniques. Eventually, one of the widely used methods to evaluate technology-enhanced learning in this study is considerably explained.

Chapter 3 describes the research method and procedures used in this study in order to address the research problems. This chapter comprises of two main research steps. The first step discusses the design and development of the adaptive e-learning system. One commonly known instructional system design is adopted in this study. Each phase that consisted of analysis, design, development, implementation, and evaluation is discussed thoroughly. Since the instructional system in this study has a strong correlation with software development, hence the software engineering is also deliberated in this step. The second step explains the methodology used in the experimental study. It begins with a discussion of the appropriate research design. Then, the strategy to select a sample as a research subject is also explained. In the next stage, the construction of research instruments in order to collect the desired data is illustrated. Furthermore, this chapter also mentions the procedures for collecting and analyzing the data. Last but it is essential in working in social science matters, the ethical issues are informed clearly.

Chapter 4 elucidates the research findings based on the statistical methods in order to prove the study hypotheses. There are two main objectives in this study, first is explaining the research results concerning the knowledge achievement reached by both groups students who either experience with or without the adaptive e-learning. The second

objective is discussing not only the usability evaluation of the personalized e-learning system but also the relationship amongst variables used in the usability questionnaire.

Finally, Chapter 5 discusses and also concludes the main findings of the study connected to the relevant literature and other similar researches. This chapter also highlights the limitations of the study and points out the potential future works.

1.7. Summary

Learning is basically a communication process between a teacher and students. In communication, there are typically three important components. First is the sender or the person who sends the message or information, and the second is a receiver or the person who receives the information delivered by the sender. Another component is a medium of communication, which can include verbal, media-based, or technological-aided. The communication medium is one of the essential factors in the success of the learning process. The appropriate learning media that is in line with the students' needs may stimulate higher students' achievement.

The main objective of the learning process is an achievement of students towards a certain level of knowledge provided by a teacher. One thing that should be considered is the students feeling comfortable in acquiring knowledge. The more convenient the students learn, the better the achievement obtained by the students. Therefore, this study proposes the utilization of computer technology in providing the learning environment that fits the student's preferences. Due to the fact that the design and development of the e-learning environment is a crucial factor, this study carefully looks at some important aspects that may influence the learning process.

2

LITERATURE REVIEW

2.1. Introduction

This chapter discusses the relevant theoretical contributions as a basis to support the main objective of the study. This literature-work associates with the academic-oriented review, which includes previous research available from the academic journals, conferences, books, or any other scientific publications. This chapter comprises of the review of the Indonesian education system, e-learning and its adaptivity, learning style, the concept of knowledge, and usability evaluation. This chapter also specifies the hypotheses revealed in the study.

2.2. Overview of the Indonesian Education

The education system in Indonesia should have the capability to manage a large, diverse, and widely dispersed population. The total number of population in Indonesia ranks three in the Asia region just after the People's Republic of China and India, and the fourth largest in the world right below the United States. A total of more than 230 million (Badan Pusat Statistik, 2010) people lives spread across more than 17,000 islands (Indonesia, 2017) from Sabang on the west-end until Merauke on the east-end. There are more than 700 distinct regional languages (Lewis, 2009) with Bahasa Indonesia as the official language which is based on the Malay trade dialect. The government officially recognizes six religions: Islam, Protestantism, Catholicism, Hinduism, Buddhism, and Confucianism, with around 87% of Indonesian people are adhering to Islam (Badan Pusat Statistik, 2010). Accordingly, Indonesia's education system today is trying to reflect those aspects of cultural, ethnic, religious, and linguistic diversity for becoming the national identity. Therefore, the national framework of education in Indonesia is created based on a strong relationship with Indonesia's national motto, Bhinneka Tunggal Ika (Unity in Diversity).

2.2.1. The Indonesian School System

Both the Ministry of Education and Culture (MoEC) and the Ministry of Religious Affairs (MoRA) are responsible for managing the education system. The former manages around 84% of general and vocational schools while the latter is responsible for about 16% of Islamic-based schools (OECD/Asian Development Bank, 2015).

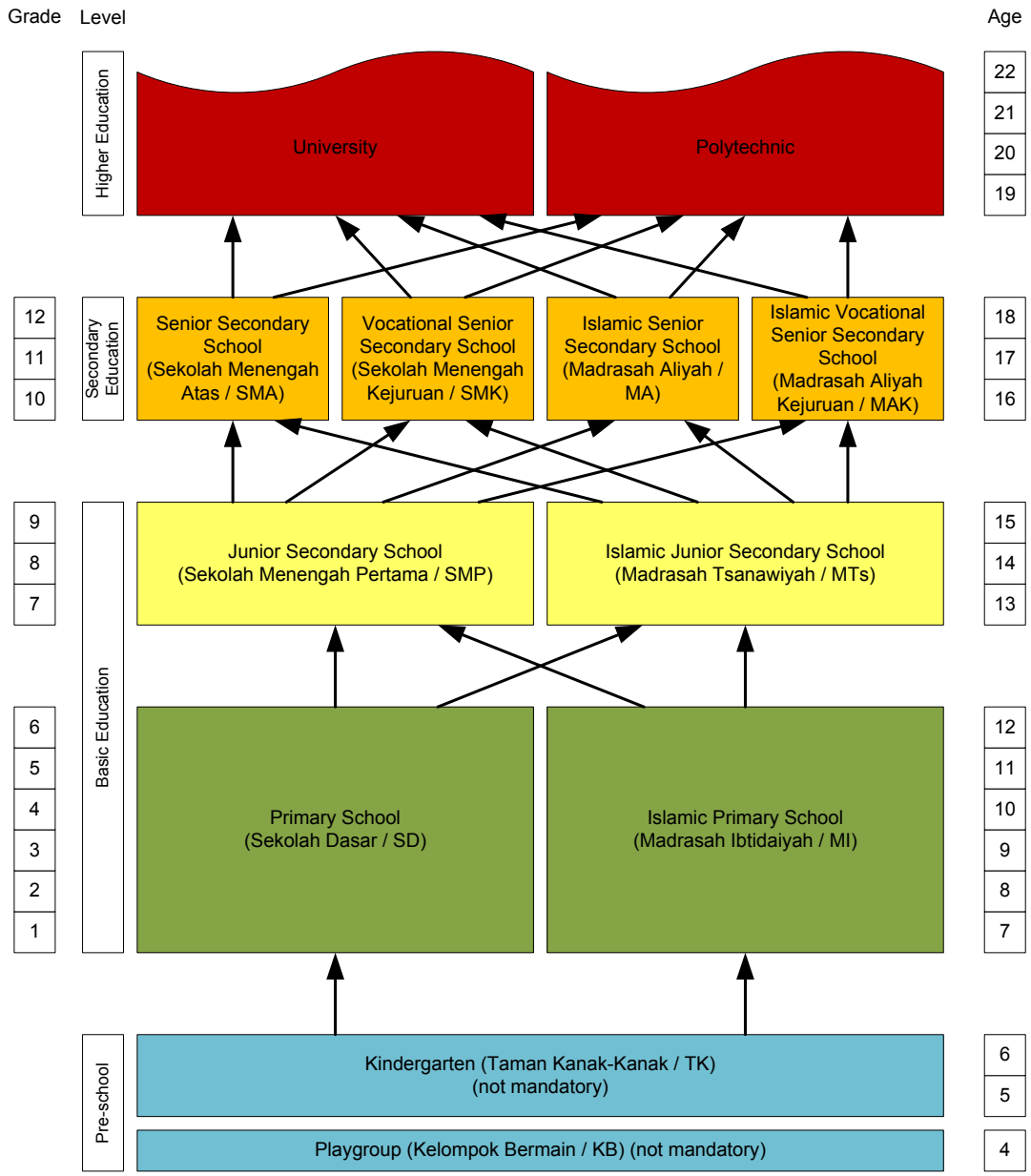


Figure 1. Indonesian school system

As Figure 1 shows, the formal education system in Indonesia is divided into four levels: pre-school, basic education, secondary education, and higher education. The entire education years that should be taken by Indonesian from basic education until Doctoral level is 21

years. From the pre-school level up to secondary level, education is managed under two systems. The first system is related to the decentralized system, where the district level is responsible for education management, and the MoEC is responsible for overall governance. The second system is associated with the centralized system in which for Islamic-based schools, MoRA is responsible for conducting both governance and management. Different situation in the higher education level where the system is centralized under either MoEC for general or MoRA for Islamic institutions.

Pre-school lasts for three years and is for children between four to six years old. This pre-school level is not compulsory for Indonesian children; it aims to help children grow and develop physically and mentally and to prepare them for primary schooling. Pre-school is commonly divided into two levels, one year in playgroup and continuing with two more years in kindergarten. Much of pre-level schools are provided by non-formal institutions.

The following level is basic education, which covers nine years of education in total: six years in primary school and three years in junior secondary school. These both primary and junior secondary levels are provided by a combination of public and private schools. The basic education is under the responsibility of MoEC for the general one (primary school or Sekolah Dasar/SD and junior secondary school or Sekolah Menengah Pertama/SMP) and under the responsibility of MoRA for Madrasah Ibtidaiyah or MI and Madrasah Tsanawiyah or MTs (Depdiknas, 2003). For the primary school, though it is common to find the children to enroll in 6 years old, however, the entry age officially is 7 years old. In 1994, the government initiated basic education as a “Nine-Year Compulsory Education” program (Program Wajib Belajar Pendidikan Dasar 9 Tahun). But then it revised by extending compulsory education into 12 years or until senior secondary level (MoEC, 2013).

After completing basic education, pupils may attend three years of senior secondary education. The senior secondary education level comprises general senior secondary school or Sekolah Menengah Atas (SMAs) as well as vocational senior secondary school or Sekolah Menengah Kejuruan (SMKs), either in Islamic and non-Islamic institutions (Depdiknas, 2003). The Islamic-based senior secondary school is known as Madrasah Aliyah (MAs), and The Islamic-based vocational senior secondary school is recognized as Madrasah Aliyah Kejuruan (MAKs). The MoEC is responsible for the SMA, and the MoRA manages the MA and MAK. Typically, the graduates from SMA are prepared for continuing their education to the higher education level, and those from SMK are planned to be skillful workers for

fulfilling the labor market. However, it is also possible for the SMK graduates to continue to further education as long as they can pass the enrollment process.

The final tier in Indonesia is higher education, which is according to Education Law No. 20 of 2003 (Depdiknas, 2003) and Higher Education Law No. 12 of 2012 (Depdiknas, 2012) categorized into six types of Higher Education Institutions (HEI):

- University (Universitas) is a higher education institution, which organizes academic education and may organize vocational education in various clusters of science and/or technology and, if eligible, may organize professional education.
- Institute (Institut) is a higher education institution, which organizes academic education and may organize vocational education in some particular clusters of science and/or technology and, if eligible, may organize professional education.
- College (Sekolah Tinggi) is a higher education institution, which organizes academic education and may organize vocational education in one particular cluster of science and/or technology and, if eligible, may organize professional education.
- Polytechnic (Politeknik) is a higher education institution, which organizes vocational education in various clusters of science and/or technology and, if eligible, may organize professional education.
- Academy (Akademi) is a higher education institution, which organizes vocational education in one or several particular branches of science and/or technology.
- Community College (Akademi Komunitas) is a higher education institution, which organizes vocational education equivalent to one-year and/or two-year diploma program in one or several particular branches of science and/or technology-based on local advantages or to meet special needs.

2.2.2. Vocational Education and Training in Indonesia

In Indonesia, the vocational education and training sector is provided through both formal and non-formal education institutions and commonly will issue certificates, diplomas, or degrees as recognition of graduation. Vocational education and training in Indonesia spread along from the senior secondary level until university level. There are generally five types of technical vocational providers which well recognized in Indonesia (OECD/Asian Development Bank, 2015).

The first type lies at the senior secondary level, is well-known as the vocational senior secondary schools or SMKs and the Islamic-based vocational senior secondary schools or MAKs. The SMK is under the responsibility of MoEC, and the MAK is under the management of MoRA. Nevertheless, the operational activities for both SMK and MAK fall under the responsibility of district or municipal governments.

The second type of vocational training is community colleges or Akademi Komunitas (AKs). This AK's level is right after the senior secondary level or post-secondary education. This college is offering a more specific subject that meets the labor market needs. This program lasts from one to two years and organized by existing SMK or higher education institutions. The graduates from this program may continue their education to the next level either into the vocational program (i.e., 2-year until 4-year Diploma) or into the academic program or Bachelor degree.

The third and fourth types are polytechnics and universities establishing at the tertiary education level. These types are offering 1-year until 4-year program or commonly called a Diploma I, II, III, and IV. This program is now under the management of the new Ministry of Research, Technology, and Higher Education (MoRTHE) that is combining the former Directorate-General for Higher Education (DGHE) and the Ministry of Research and Technology (MoRT).

The last type is vocational centers or generally known as Balai Latihan Kerja (BLKs). This type provides non-formal technical and vocational education and training (TVET) and falls under the administration of the Ministry of Manpower and Transmigration (MoMT). This program offers a "second chance" specific vocational training for students who dropped out on primary and secondary education (OECD/Asian Development Bank, 2015).

The government puts the development of vocational education and training sector as a main priority to support an essential strategy for economic growth. As a consequence, there is a significant expansion of vocational education and training over the past decade, particularly in vocational senior secondary schools or SMK. To overcome a need for diverse skills set, many options are provided by vocational secondary education. There are nine main available areas of expertise including technology and engineering, energy and mining, information and communication technology, health care and social care, agribusiness and agro-industry, maritime, business and management, tourism, and arts and creative industry (Dikdasmen, 2016). Each main area offered is divided into several sub-areas of more

specific competencies. The main goal of a vocational school is to prepare students to enter the labor market immediately, especially for those who do not envision continuing to the higher education level. In pursuit of that objective, vocational education and training offer a higher proportion of vocational subjects to ensure students acquire the occupational skills needed in the workplace.

2.2.3. Issues and Challenges in Indonesian Vocational Education

With hundred millions of population and the diversity of cultural, ethnic, religious, and linguistic, education in Indonesia faces huge challenges. The political, economic, and social aspects are also influencing the direction of development policy in Indonesia's education. The significant high growth of information and technology is also an important part that cannot be ignored in the development of many sectors, especially in education in Indonesia. The following are some significant issues and challenges that emerged in Indonesian vocational education and training:

Strategic plan on senior secondary education

The strategic plan from MoEC is to try to increase the existence of vocational education schools at a more significant number than the general senior secondary education schools. The MoEC aims to reverse the ratio of SMA to SMK students from 60:40 in 2009 to 50:50 in 2015, and the final ratio become 70:30 in 2025 (Departemen Pendidikan Nasional, 2005). The policy about the ratio of SMA vs. SMK expects to get the percentages of 30% and 20% of the labor force from the graduates of SMKs and SMAs respectively by 2025 (Kadir, Nirwansyah, & Ayasha Bachrul, 2016).

In order to address that goal, the MoEC takes into account several strategies. The first one is by stopping or more selective in the establishment of new SMAs. Converting the existing SMAs into SMKs by still considering certain aspects is another way taken by the MoEC. The establishment of new SMKs is also conducted with regard to specific skills needed by the labor market. In 2015, the Minister of Education and Culture said that there would be the accelerated establishment of new 200 SMKs specializing in agriculture, tourism, infrastructure, and manufacturing (Suciati Saputri & Zuhri, 2015).

The increasing number of SMKs is causing consequently other problems such as the preparation of a new workshop including its instruments or tools, the readiness of teachers

specifically in vocational skills, and other things. These problems should be taken into consideration by MoEC as a central policymaker in education.

Paradigm amongst Indonesian parents

There is an old conception amongst Indonesian people that the SMK is chosen as a second choice than SMA. This phenomenon emerged based on the fact that the graduates from SMK are prepared for ready to work or to be skillful workers rather than those who graduated from SMA. The graduates of SMA are prepared to continue their education to the next level of education or the higher education level. To this end, continuing education in higher education needs relatively much financial support.

Though some higher education institutions provide various options of scholarship, however, the number of scholarships cannot be covering all of the students. The financial issue in the higher education level is the main reason for parents to decide the SMK as a reasonable choice. This comes from the fact that most of the Indonesian people's economy is in the income level of low and medium. Another reason is the graduates of SMK prepared well to work; it means that they will get into industries or factories for working afterward and can comfortably live independently.

This paradigm may lead to the enrollment trend in the SMK increasing from year to year than in the SMA. Accordingly, there will be a bigger number of students in SMK that need well-structured education treatment in order to get skillful graduates.

The involvement of ICT in education

Recently, the growth of Information and Communication Technology (ICT) is tremendous, including in Indonesia. ICT also plays an essential role in many aspects of life, in which one of them is in the education sector. The Asian Development Bank gave a strong point on the importance of ICT in strengthening vocational education and training as a crucial part of the transition to a knowledge-based economy (Asian Development Bank, 2009).

The survey conducted by the Indonesia Internet Service Provider Association in 2017 (APJII, 2017) revealed that the penetration of internet use in Indonesia significantly increased from year to year. The report also showed that there is 54.68% (143.26 million from 262 million) of Indonesian populations who have accessed the internet. It also evidenced that 16.68% of internet users are at the secondary school age (13 to 18 years old). It is clearly

seen that it needs some specific strategy from the government through MoEC to use the potential of the internet for supporting the teaching and learning process.

To meet that situation, MoEC has identified three strategies in the involvement of ICT in the National ICT implementation program (Kadir et al., 2016; Kementerian Pendidikan dan Kebudayaan, 2010). The first strategy is to use ICT in the development of online learning in order to improve access to and quality of education for Indonesians, particularly in rural and border areas. The next strategy is to use ICT in school management in order to increase efficiency and transparency. The last approach is to use ICT as a tool to share information for the education sector.

Although some vocational senior secondary schools show good investments and resources in ICT infrastructures and internet access, some other schools are still struggling with the availability of those things.

2.3. E-Learning and its Adaptivity

In the digital age, it is inevitable that traditional classroom learning may shift into technology-aided education considerably. The enormous growth of information and communication technology may bring the invention of electronic devices to support the learning and teaching process. In the 1990s, the existence of video-tape, OHP (Over Head Projector), and CD-ROM was often be used by teachers for helping to deliver the course material. Recently, the euphoria of computers and internet brings the new model of learning in which it may conduct wherever and whenever. E-learning technology may provide the course to the students either in online or offline mode. The old model of e-learning typically offered the same material to all students as same as it provided by the teachers in the classroom setting. As e-learning technology continuously evolved, one of the latest technologies in e-learning now is the capability to suit its learning environment for each different student's characteristics.

2.3.1. E-Learning

In the information and communication age, the learning process can rely upon a personal computer and Internet connection as a channel. The students do not have to be in the same place and at the same time as the teacher. Nevertheless, the students can acquire knowledge as well as they can in the traditional classroom. This type of learning is commonly known as e-learning. Clark (2002) defined e-learning as content and instructional

methods delivered on a computer using specific modes such as CD-ROM, internet, or intranet, and designed to build knowledge and skills related to individual or organizational goals. The “e” in the term “e-learning” refers to how the course is transformed and stored in digital form and then delivered through electronic modes (Clark & Mayer, 2016). These are the following characteristics of e-learning identified by Clark & Mayer (2016):

- It includes the content referred to the learning objective.
- It uses instructional methods such as examples and practice to help the learning process.
- It uses some media elements such as words and pictures to deliver the content and methods.
- It may be constructed either in instructor-led (synchronous e-learning) or designed for self-paced individual study (asynchronous e-learning) mode.
- It should be able to build new knowledge and skills associated with individual learning goals or to improved organizational performance.

Due to the enormous rise of internet users and network technology, e-learning has become a popular choice amongst internet users. According to Rosenberg & Foshay (2002), e-learning depends on internet technology and is typically a networked form of traditional learning paradigms. E-learning is not limited to a specific time and place as traditional classroom instruction. Users can access the e-learning whenever and wherever they want (Chen & Zhang, 2008).

However, the definition of e-learning still can be interchangeable between online learning, technology-mediated learning, web-based learning, or distance learning (Conrad, 2006). Some other practitioners and researchers consider that those terms can be used synonymously (Dringus & Cohen, 2005; Khan, 2001; McKimm, Jollie, & Cantillon, 2003; Triacca, Bolchini, Botturi, & Inversini, 2004). Nevertheless, there is some uncertainty to describe the unique characteristic of e-learning, but one of the most apparent features of e-learning is they could be as applications, programs, objects, websites, etc., that eventually provide a learning opportunity for individuals (Moore, Dickson-Deane, & Galyen, 2011).

2.3.2. Adaptive E-Learning System

The advancement of technology brings the development of e-learning at a more sophisticated level, which involved an adaptive or intelligence ability. On the traditional

"static" e-learning applications, they only have the capability to provide the same content and navigation to all participants (Brusilovsky, 2000). The traditional e-learning system is merely replicating what it is conducted in the conventional face-to-face learning process into the new form of technology-based learning. They are still following the "one-size-fits-all" strategy as the traditional classroom setting does. One of the shortcomings of the static e-learning is suffering from an inability to respond to the relatively diverse user's characteristics.

Adaptive e-learning is an alternative approach to overcome the problem of learner diversity. This "dynamic" e-learning does not adhere to the standard flow of static e-learning. This adaptive e-learning can be used to provide a different e-learning environment to suit the user's preferences. In an adaptive e-learning system, the application could offer a suitable presentation to the specific level of knowledge of a particular user (Bra & Calvi, 1998), and propose a set of most relevant links to navigate on the e-learning environment (Brusilovsky, Eklund, & Schwarz, 1998).

There is uncertainty when exactly the adaptivity approach in e-learning starting to be used in education application. However, the strategy used in the adaptive e-learning mechanism was inspired by the intelligent tutoring system (Brusilovsky, Schwarz, & Weber, 1996; Gonschorek & Herzog, 1995; Hauger & Köck, 2007; Pérez, Gutiérrez, & Lopistéguy, 1995; Shute & Towle, 2003). In the early development stage of the Intelligent Tutoring System (ITS) and due to the limitations of computer's ability, ITS system was built limited to support students specifically in the problem-solving process rather than to provide the whole learning material (Brusilovsky, 2000). It meant that in order to get knowledge in a certain subject, the students still need to acquire from other resources outside the ITS system, e.g., taking a lecture or reading a textbook. As time goes on and the advance of computer capability, the ITS was becoming an instructional system that offered a learning material and instructional strategy in one package. Shute & Psotka (1994) mentions that the ITS is developed to replicate the role of the one-on-one, personalized tutoring, between the teacher and a student. ITS has to represent the learning content structurally and implement the instructional strategy. The combination of both structured content and instructional approach in the ITS was a starting point for the research of adaptive educational hypermedia system.

Subsequently, in the early 1990s, the Adaptive Hypermedia System (AHS) as a derivative from ITS was born (Mödritscher, Garcia-Barrios, & Gütl, 2004). AHS is trying to put the hypermedia-based function into an adaptive instructional system, where the adaptive mechanism and the learning interfaces are integrated into a hypermedia system (Eklund & Sinclair, 2000). Hypermedia is an extension of the term hypertext. Hypertext is strongly related to providing a specific action when a specific text to be clicked. Then hypermedia is allowing multimedia such as images, movies, graphics, and other media to behave like hypertext. On that point, adaptive hypermedia can be used in educational hypermedia (Bra & Calvi, 1998; Brusilovsky & Eklund, 1998; Weber & Brusilovsky, 2001), e-commerce application, information system, and help system (Brusilovsky, 1996). Adaptive educational hypermedia provides an educational system capable of fitting the student's needs, knowledge, or preferences by delivering the most relevant hyperlinks in the form of multimedia objects.

Many e-learning applications are developed based on web programming. The web-based platform is chosen because of its feasibility to be accessed by many users in one time either in a local network or internet. The web-based adaptive e-learning hereinafter popularly known as adaptive e-learning is developed on the basis of adaptive educational hypermedia (De Bra, Aroyo, & Cristea, 2004). The main objective of adaptive e-learning is delivering the most relevant content for each different person through the most appropriate way - any time, any place, any path, any pace (National Association of State Boards of Education, 2001).

Since the adaptive e-learning is developed based on the adaptive hypermedia system, thus the most common framework followed the adaptive hypermedia system. The Adaptive Hypermedia Application Model (AHAM) proposed by De Bra et al. (1999) as an extension of the Dexter model (Halasz & Schwartz, 1994) has three fundamental components: a domain model, a user model, and an adaptation model. The domain model focuses on the structure of the content in the form of pages, and the links which connected between those pages. The user model stores the user information (knowledge, behavior, or preferences) that can be used as a data input for the system. The adaptation model consists of a set of adaptation rules for performing adaptive mechanisms on the domain model from the input of the user model.

2.3.3. Adaptivity in E-Learning System

In the context of web-based education, there are two research challenges in the development of advanced learning applications, the first one is providing the adaptivity on the system and the second is focused on the intelligence techniques (Brusilovsky & others, 1999). In the context of adaptive, adaptive e-learning is a kind of e-learning system in which has the ability to provide the content to the learner and adjust the content to suit the need of a particular learner based on the learner characteristics (Jevremović & Vasić, 2010; Shute & Towle, 2003). Since the students have differences in many aspects, the adaptive e-learning is the key to overcome these differences and make the learning easier (Melicherikova & Bušíková, 2012). Adaptivity is one of the most important keys to deal with differences barriers amongst the learners. Kareal & Klema (2006) suggested an adaptivity rule as an essential part of the effective educational process, and it should be implemented in e-learning systems as well. According to the definitions from some experts above, it can be concluded that adaptive e-learning is one of the e-learning systems in which has the capability to accommodate the suitable environment and content amongst differences student's preferences in order to gain the effectiveness in the learning process.

Furthermore, in terms of intelligence in web-based education, intelligence is one of the terms of Artificial Intelligence. Munakata (2008) said that there is no exact standard definition of Artificial Intelligence amongst computing professionals. Artificial Intelligence is the study of ideas that enable computers to be intelligence (Winston & Brown, 1984). Nilsson & Nilsson (1998) explained that Artificial Intelligence is concerned with intelligent behavior in artifacts. Similar to Nilsson's opinion, Whitby (2009) mentioned that Artificial Intelligence is the study of intelligent behavior and the attempt to find ways in which such behavior could be engineered in any type of artifact. According to some definitions about Artificial Intelligence, Russell & Norvig (2016) organized the definitions of Artificial Intelligence into four categories: thinking humanly, acting humanly, thinking rationally, and acting rationally. More specific, intelligent in web-based education is usually known as Intelligent Tutoring Systems, which is one of the fields of application for Artificial Intelligence techniques (Melis & Siekmann, 2004).

The term "adaptive" and "intelligence" are not really similar, the intersection is still large, and the borders between both of them are not clear-cut (Brusilovsky & Peylo, 2003). Brusilovsky & Peylo (2003) has defined the adaptive system as the system that acts

different for different students based on the student models and has identified the intelligent system as the system that applies Artificial Intelligence techniques to provide broader and better support for the users of educational systems.

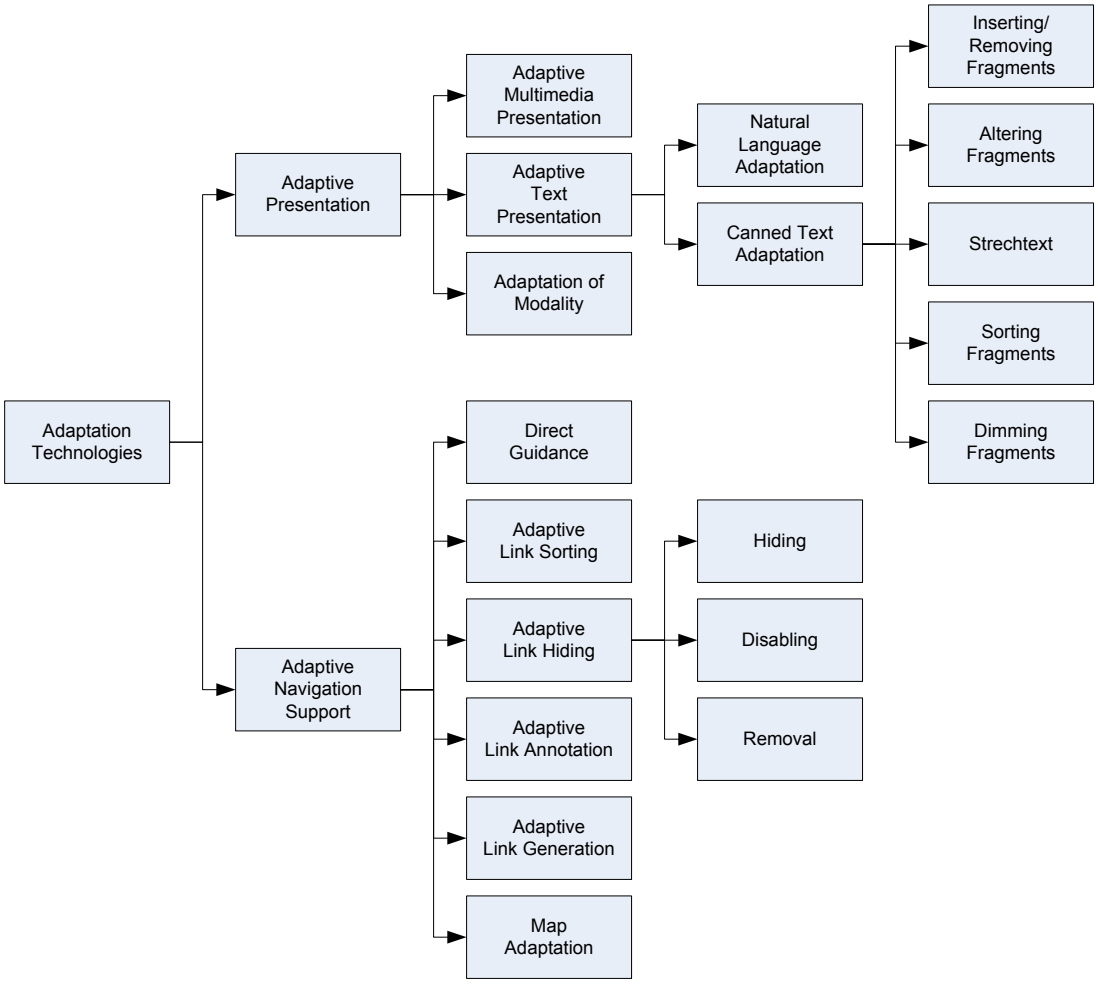


Figure 2. The updated taxonomy of adaptive hypermedia technologies

In the context of adaptive, Brusilovsky (2001) called as Adaptive Hypermedia System, the system that builds a model of preferences for a different individual user, and use this model throughout the interaction with the user, in order to adapt to the needs of that user. According to Brusilovsky (1996), there are two types of adaptation in e-learning terms; the first one is adaptation related to the content of regular pages (content-level adaptation) and the second is an adaptation on the links from regular pages, index pages, and maps (link-level adaptation). It is distinguished between content-level and link-level adaptation as two different classes; the former is an adaptation in presentation and the latter is an adaptation in navigation support. Figure 2 shows Brusilovsky's taxonomy of adaptive hypermedia technologies (Brusilovsky, 2001b), updated from (Brusilovsky, 1996).

2.3.3.1. Adaptation in Presentation

The goal of an adaptive presentation is to adapt the content presented in each page to different student preferences. The preferences of students could be obtained from current knowledge, goals, and other specific characteristics of learners. There are two kinds of adaptation in presentation, namely adaptive in text presentation and adaptive in a multimedia presentation. Adapting the presentation of information in the learning environment is basically a manipulation of a (canned) text fragments. This manipulation also can be applied for the multimedia format.

De Bra, Brusilovsky, & Houben (1999) divided the adaptation in the presentation into three manipulation techniques:

- Providing prerequisite, additional or comparative explanations. This technique is conducted by providing a missing prerequisite knowledge, extra details, or a comparison with a current known concept for users with a specific state of knowledge. There are several ways to tackling this technique: conditional inclusion of fragments (De Bra & Calvi, 1997), and stretch or shrink (text) fragments (Boyle & Encarnacion, 1998).
- Providing explanation variants. The concept of this technique is trying to present the same information in different ways. The way of presentation can be depended on the difficulty level, the related concepts a page refers to, the presentation length, the media type (text, images, audio, or video) or other aspects that may be changed.
- Reordering information. This technique emerged based on the idea of ordering the information from the most relevant one that fits the user's preferences.

2.3.3.2. Adaptation in Navigation Support

The goal of adaptive navigation support is to assist the student in the learning environment by providing a suitable learning path. Adaptive navigation support deals with all the possibilities to modify the links visually in order to navigate in e-learning pages. Brusilovsky (1996) divided various method for adaptive navigation support as follows:

- Direct guidance: This is the simplest technique for the adaptation in navigation support. This technique works based on the concept of traditional sequential learning mechanisms (Brusilovsky, 1992). The typical component used to represent this technique is the availability of the "next" or "continue" link or button to

navigate sequentially within the learning environment. There is also an option for going back to the previous information by applying the “prev” link or button.

- Link sorting: The idea of the link sorting or ordering techniques begins with sorting all the links on a particular page in the learning system based on some pre-determined criteria, for instance, the higher to the top, the more relevant the link is.
- Link hiding: The aim of the navigation support by hiding the link is to restrict the user to navigate throughout the learning environment based on an inappropriate or irrelevant page to provide to the user. The link hiding has subdivided into more detail by Calvi (1998) into three classes: a) (pure) link hiding, means that the link is still there, but it is made invisible for the user by modifying the link anchor undetected visually; b) link removal, means that the link is clearly removed from the learning page; and c) link disabling, means that the link is not invisible, but it doesn't work functionally.
- Link annotation: The concept of the link annotation technique involves presenting a link or button through some form of visual cues for the relevant information. These annotations might be provided with different colors, icons, arrows, or font-sizes.
- Map annotation: The concept of the map annotation is following the link annotation techniques, but this is for adapting graphical and/or maps-based annotation.
- Link Generation: It is the “newest” adaptive navigation support technology added by Brusilovsky on the updated taxonomy of adaptive hypermedia technologies (Brusilovski, Kobsa, & Nejdl, 2007). A different concept with link annotation, sorting or hiding techniques that adapt the presentation of pre-existing links by manipulating them visually, link generation actually creates a new link on the page.

2.3.4. Previous Works in Adaptive E-Learning System

The development of an adaptive e-learning system has been conducted for decades by many practitioners or researchers around the globe. Many adaptive e-learning applications with its specific personalization have been designed, developed, implemented, and tested in order to achieve the same goal in providing a suitable learning environment for users. This section lists previous works in an adaptive e-learning system. It provides an overview of the existing adaptive e-learning systems that are developed based on the user’s learning style or knowledge level or the combination of both those aspects of personalization. These personalization aspects used are expected to improve the efficiency and effectiveness of

the learning process. Student satisfaction can be achieved as well (Popescu, Badica, & Moraret, 2010). The series of well-known adaptive e-learning system from the 1990s are presented in Table 1. This table explains an overview of the adaptive e-learning system by providing brief information, particularly on the aspects of personalization used in each system.

Table 1. Previous works in the adaptive e-Learning system

Adaptive E-learning System	Single/Multi Aspect(s)	Aspect(s) of Personalization	Learning Style Model
ELM-ART (Brusilovsky et al., 1996)	Single	• Knowledge level	None
CS383 (Carver, Howard, & Lane, 1999)	Single	• Learning style	Felder-Silverman model
MANIC (Stern & Woolf, 2000)	Single	• Preferences	None
MAS-PLANG (Peña, Marzo, & de la Rosa, 2002)	Multi	• Knowledge level • Learning style	Felder-Silverman model
AES-CS (Triantafillou, Pomportsis, & Demetriadis, 2003)	Single	• Cognitive style	Witkin model: Field dependence and field independence
INSPIRE (Papanikolaou, Grigoriadou, Kornilakis, & Magoulas, 2003)	Multi	• Knowledge level • Learning style	Honey and Mumford model
iWeaver (Wolf, 2003)	Single	• Learning style	Dunn and Dunn model
AHA! (De Bra et al., 2003)	Single	• Learning style	Multiple learning style models
MOT (Cristea & De Mooij, 2003)	Single	• Knowledge level	None
PHP Course (Hong & Kinshuk, 2004)	Single	• Learning style	Felder-Silverman model
TANGOW (Alfonseca, Carro, Martin, Ortigosa, & Paredes, 2006)	Single	• Learning style	Two dimensions of the Felder-Silverman model: Sensing-intuitive and sequential-global
WHURLE-LS (Brown, Brailsford, Fisher, Moore, & Ashman, 2006)	Single	• Learning style	One dimension of the Felder-Silverman model: Visual-verbal

DesignFirst-ITS (Parvez, 2007)	Single	• Learning style	Felder-Silverman model
Algorithm Course (Velázquez & Assar, 2007)	Single	• Learning style	Felder-Silverman model
AES (Surjono, 2007)	Multi	• Knowledge level • Learning style	Sequential-global and visual-verbal
eTeacher (Schiaffino, Garcia, & Amandi, 2008)	Single	• Learning style	Two dimensions of the Felder-Silverman model: Active-reflective, sensing-intuitive and sequential-global
LS-Plan (Limongelli, Sciarrone, Temperini, & Vaste, 2009)	Multi	• Knowledge level • Learning style	Felder-Silverman model
WELSA (Popescu, 2010)	Single	• Learning style	Unified learning style model
Protus (Klašnja-Milićević, Vesin, Ivanović, & Budimac, 2011)	Multi	• Preferences • Learning style	Felder-Silverman model
LearnFit (Essaid El Bachari & El Adnani, 2011)	Single	• Learning style	Myers-Briggs Type Indicator
OSCAR CITS (Latham, Crockett, McLean, & Edmonds, 2012)	Single	• Learning style	Felder-Silverman model
POLCA (Dung & Florea, 2013)	Single	• Learning style	Felder-Silverman model

As can be seen in the list of an adaptive e-learning system above that most of the applications in e-learning was used a user's learning style as a personalization aspect of adaptation. It is interesting to note that the majority of the learning style model used in the adaptive e-learning system is the model from Felder-Silverman (Felder & Silverman, 1988). It is also indicated that other learning style models such as the Dunn and Dunn model (Rita & Dunn, 1993), Honey and Mumford model (Honey & Mumford, 1992), Myers-Briggs Type Indicator (Myers, McCaulley, Quenk, & Hammer, 1998), Witkin model (Witkin, Moore, Goodenough, & Cox, 1977), Multiple learning style models (De Bra et al., 2003), and Unified learning style model (Popescu, 2010) are not frequently used. The Felder-Silverman learning style model is often adopted in the adaptive e-learning application because it offers a more detail classification of learning style. This Felder-Silverman model arranges

the learning style into four dimensions in which for each dimension spans along two different poles. The dimensions organize as active-reflective, sensing-intuitive, visual-verbal, and sequential-global.

Another aspect used as personalization in the adaptive e-learning system is knowledge level. It is quite common in the learning process to measure the initial level of knowledge of each student before the learning starts. This process is typically conducted through the pre-assessment by collecting the pre-test score. As it also performed in the e-learning system, the e-learning application needs to know the student's knowledge level in order to provide the appropriate learning content and learning path.

Other adaptive e-learning systems use specific preferences as an adaptation aspect. The MANIC (Stern & Woolf, 2000) adaptive e-learning system describes student's preference by taking into consideration of two factors: how much a student knows about a concept and how the student likes to learn it. Meanwhile, the Protus system (Klašnja-Milićević et al., 2011) identifies student's preference by analyzing the habits and interests of students through mining the frequent sequences of learning activities. At this point, it can be noted that many adaptation algorithms have been created by researchers in order to meet the student's needs.

Taking closer into the number of personalization aspects used, it can be seen that some adaptive e-learning systems deal with a single aspect and others prefer multi aspects. Most of the single aspect is utilizing the learning style as a variable of personalization. Meanwhile, most of the multi-aspect personalization is using a combination of user's knowledge level and learning style. These pieces of evidence might come from the tendency that the more aspect used in the adaptation algorithm; the more learning personalization may fit the user preferences.

2.4. Learning Style

Learning style refers to the most convenient way for the student to absorb, process, and comprehend the information provided by the teacher. This comes from the understanding that individuals take in and process information and knowledge in different ways based on their individual preferences (Vincent & Ross, 2001). There is no right or wrong to which learning style is the best; some may find they have more dominant in one particular style; others may prefer different styles.

Some individuals more effectively perceive information in visual form, i.e., pictures, diagrams, charts, graphs, and demonstration, than in verbal form, words, and sounds. Others prefer to process information in active ways, through physical activity or discussion, rather than reflective or through observation. Some more easily understand the material in sequential steps, while others prefer a global view. Some learn by gathering data through the senses, while others prefer to learn by intuitively figuring things out. Each of these learning methods is valid and also very helpful, in accordance with each individual's learning style.

Research on the Dunn and Dunn model of learning styles has determined that every individual has his/her specific learning style and unique learning style strengths (Dunn, 1990). The model also suggests that it is much more effective to teach individuals by capitalizing on their own personal strengths.

2.4.1. Learning Style Models

Many different learning style models have been developed by researchers and practitioners. Those models have the same objective to classify the student's learning styles according to their individual learning preferences. By knowing the learner type, teachers can use it to provide suitable materials to specific learners to enhance their learning achievement. Some of the prominent known approaches are the Kolb's Learning Style Inventory (LSI) model (Kolb, 1976), the Honey and Mumford's Learning Styles Questionnaire (LSQ) model (Honey & Mumford, 1982), the Dunn and Dunn model (Dunn & Dunn, 1989), the Myers-Briggs Type Indicator (MBTI) (Myers et al., 1998), the Visual, Aural, Read/Write, and Kinesthetic (VARK) (Fleming, 2006), and the Felder-Silverman Learning Style Model (FSLSM) (Felder & Silverman, 1988). Those learning style models will be briefly explained in the following section.

2.4.2. Kolb's Experiential Learning Model

Kolb's experiential learning model (Kolb, 1976) postulates a four-cycle structure that covers and generally starts with Concrete Experience (CE), then moves to Reflective Observation (RO), subsequently shifts to Abstract Conceptualization (AC), and finally to Active Experimentation (AE). However, it depends on the individual's preferences; the learning style may start at any stage of the modes provided in the cycle.

As seen in Figure 3, Kolb describes CE and AC as a bipolar related to modes of grasping experiences, and RO and AE as another bipolar associated with modes of transforming experiences. The varying results of a combination of two-mode preferences are Diverger (CE and RO), Assimilator (RO and AC), Converger (AC and AE), and Accommodator (AE and CE).

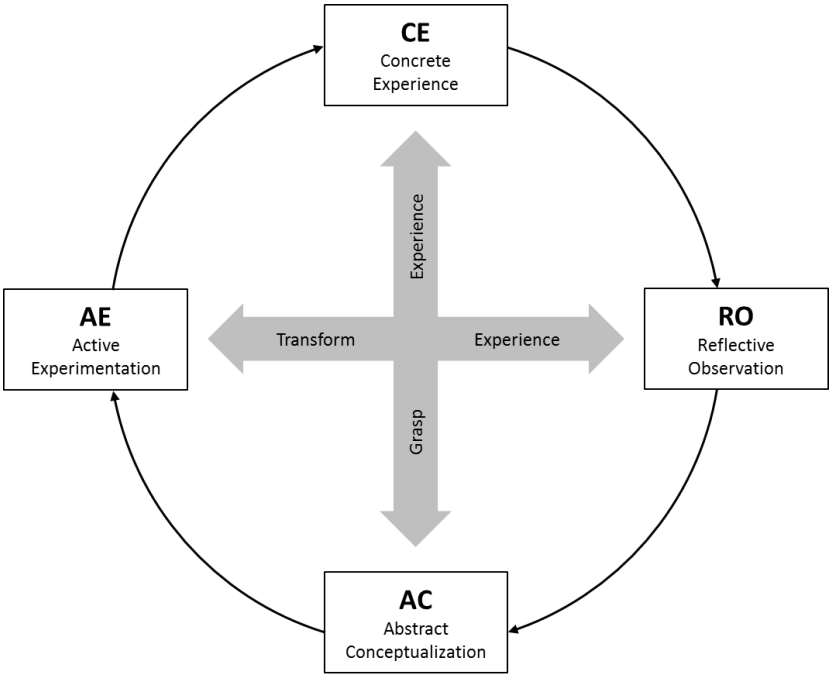


Figure 3. Kolb's experiential learning model

Individual's preferences on this model are assessed with the Learning Style Inventory (LSI), which is designed to help individuals identify the way they learn from experience. The item's number of LSI has developed over time, the LSI version 1 has a short 9 questionnaire, and the subsequent versions have 12 items. The LSI 4.0 has 20 items in which 12 of it similar to the items in the 3.1 and the remaining 8 additional items to assess learning flexibility (Kolb, 2011). All of the LSI's versions have the same format in which the individual was asked to rank four sentences that correspond to the Kolb's four learning modes.

2.4.3. The Honey and Mumford Model

Honey and Mumford's Learning Style Questionnaire (LSQ) is created based on Kolb's experiential learning model (Honey & Mumford, 1982). The LSQ was developed specifically for use in industry and management and has been proposed as an alternative to Kolb's LSI. Nevertheless, the LSQ has been used in a broad range of settings, including education. The LSQ comprises four styles that generally equivalent to the four stages of Kolb's cycle:

activist (Kolb's concrete experience), reflector (Kolb's reflective observation), theorist (Kolb's abstract conceptualization), and pragmatist (Kolb's active experimentation).

The LSQ now exists in two versions, either the original 80-item (Allinson & Hayes, 1988) or the shorter 40-item new versions (Honey & Mumford, 2000). The 80-item version is ideal for assessing the more comprehensive learning styles with 20 randomly-ordered items per style instead of 10, but the 40-item offers a quick way to establish the learning style preferences.

2.4.4. The Dunn and Dunn Model

Dunn (1990) defined learning style as "the way in which individuals begin to concentrate on, process, internalize, and retain new and difficult information. That interaction occurs differently for everyone." The Dunn and Dunn model is a comprehensive model that identifies each individual's strengths and preferences across five major categories. Each category contains several elements. Originally, this model includes 21 elements in total.

The five categories and their respective elements are: 1) the *environmental* category that includes sound, light, temperature, and room designs; 2) the *emotional* category that refers to motivation, persistence, responsibility/conformity, and structure; 3) the *sociological* category that deals with learning alone, in a pair, in a small group, as part of a team, with a teacher, and mixed; 4) the *physical* category that is concerned with perceptual strengths, intake while learning, chronological energy pattern, and mobility needs; and 5) the *psychological* category that is related to global or analytic, right or left brain, and impulsive or reflective.

Dunn, Griggs, Olson, Beasley, and Gorman (1995) conducted a meta-analysis of 42 research on the Dunn and Dunn model. The finding indicated that the educational intervention which is compatible with student's learning style is generating a good academic achievement. Nevertheless, a set of 100 items of question offered by this model for covering all elements may bring to inconvenient for the survey's takers.

2.4.5. The Myers-Briggs Type Indicator

The Myers-Briggs Type Indicator (MBTI) was developed by Isabel Briggs Myers and her mother, Katherine Cook Briggs as an individual's personality measure derived from Jung's theory (McCaulley, 1990) of psychological types. MBTI divided into four dimensions in

which for each dimension comprised two dichotomous preferences. Consequently, there are 16 possible personality types. The four dimensions of MBTI described as follows:

- Extraverted - Introverted: it explains the way people use different attitudes to direct their energy. Extraverts feel energized from active involvement and excite in a group of many people. Introverts prefer to observe before doing an activity and feel comfortable being alone.
- Sensing - Intuition: it relates to the way people perceive the information. Sensing people prefer to "learn by doing" and the practical thing rather than thinking it through and the theoretical. Intuition people are able to grasp the abstract concept and easy to see the global view rather than to go into details.
- Thinking - Feeling: it refers to the way people make decisions. Thinking people tend to be more objectives and decide the situation based on the facts. Feeling people are more subjective and consider personal values when making decisions.
- Judging - Perceiving: it describes the way people like to live their outer life. Judging people tend to follow outlined schedules and more focus on the outcome rather than the process. Perceiving people tend to be flexible to the situation and try to adapt it. They are enjoying the process more than the process.

Officially, there are 93 questions on the Myers Briggs Type Indicator test. For each item, the test's taker has to choose one from two options, which consist of word pairs and simple statements. The statements are not constructed in polar opposites form, but they are chosen to reflect dichotomy preferences.

2.4.6. The VARK Model

The acronym of VARK stands for Visual, Aural, Read/Write, and Kinesthetic. Fleming (2006) designed this VARK learning style model in 2006 as a modified version of the VAK (Visual-Auditory-Kinesthetic) model. This learning style refers to the ways people tend to take in and give out information. This preference classifies students into four main types of learners, i.e., visual, aural, read or write, and kinesthetic (Fleming, 2006).

- Visual: this type of learner prefers learning by looking at maps, diagrams, charts, graphs, flow charts, and all the symbolic arrows, circles, hierarchies. It does not include still pictures, movies, videos, or PowerPoint presentations.

- Aural/Auditory: this preference learns best through listening or speaking method. They like to involve in lectures, group discussion, radio, email, using mobile phones, speaking, web-chat, and talking thing.
- Read/write: the one who categorized in this type tends to work in text-based material. They prefer reading and writing in all its forms.
- Kinesthetic: this modality prefers to experience through concrete examples, real practice, or simulation. It includes videos and movies of "real" things.

The VARK questionnaire is relatively short, consisted of 16 statements for representing four perceptual modes. Individuals can have preferences from one to four modes. The total of all four scores ranges from 13 to 48 (Hawk & Shah, 2007). Figure 4 presents the VARK model adapted from Fleming (2001).

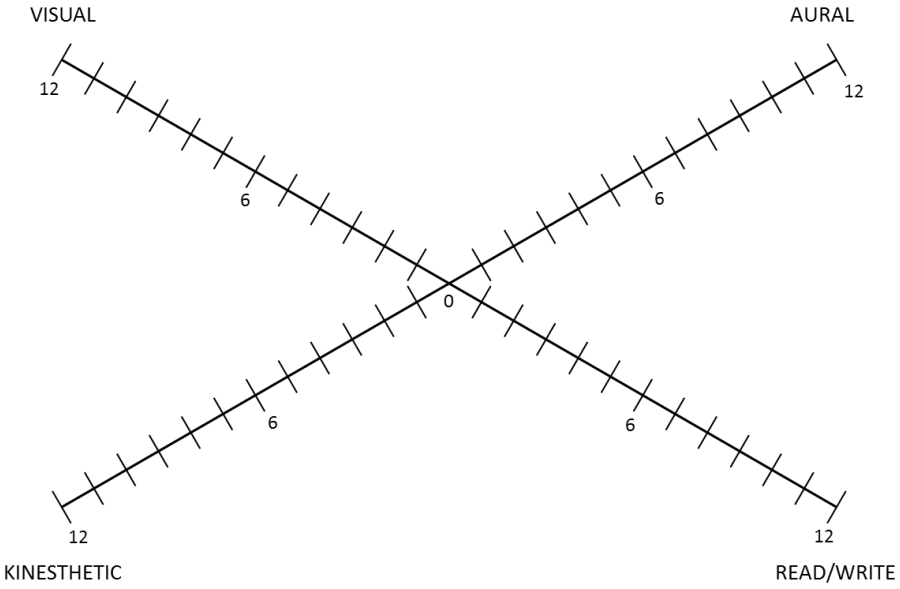


Figure 4. VARK learning model

2.4.7. Felder and Silverman Model

The most widely used learning style is FSLSM. In the context of adaptive e-learning as indicated on the lists in

Table 1 above, the majority of previous work of personalized learning application is using the FSLSM as a basis of personalization element compared with other learning style models. Felder and Silverman described the learning style in more detail, distinguishing the preferences on four dimensions (active-reflective, sensing-intuitive, visual-verbal, and sequential-global) (Felder & Silverman, 1988). The four dimensions of Felder-Silverman

mathematically produce 16 (2^4) possibilities of different learning styles, one, for instance, is the active-sensing-visual-global style.

Since this model was basically constructed in terms of engineering sciences (Hawk & Shah, 2007; Kapadia, 2008), hence it is an acceptable choice to consider this model as an adaptation aspect in the adaptive e-learning system for students in a vocational high school. FSLSM is also used very often in research related to learning styles in technology-enhanced learning (Graf, Viola, Leo, & Kinshuk, 2007). Carver et al. (1999) concluded that FSLSM is the most appropriate approach to categorize individuals with a preferred learning style in each dimension. Moreover, the studies carried out by Kuljis & Liu (2005) and Velázquez & Assar (2007) suggested that the FSLSM model is the most suitable candidate for fulfilling adaptability regarding learning differences and individual needs in an e-learning system.

The Felder model classifies learners according to a scale that reflects how learners process or take in information and how the information is presented or organized. Each dimension spans along two opposite poles that can be briefly described as follows: information processing (active-reflective), information perception (sensing-intuitive), input modality (visual-verbal), and information understanding (sequential-global) (Felder & Silverman, 1988). Table 2 describes four dimensions of the Felder-Silverman model, including their specific characteristics (Felder, 1996; Felder & Silverman, 1988).

Table 2. Felder-Silverman learning style dimensions and characteristics

Dimension	Type of Learning Style	Characteristics
Processing	Active	Prefer to learn by doing, experimentation, and working in groups.
	Reflective	Prefer to learn by thinking and observing problems for a moment and working alone.
Perception	Sensing	Prefer facts, data, and experimentation and patient with details.
	Intuitive	Prefer concepts, principles, and theories and bored with details.
Input	Visual	Prefer to perceive materials in a visual form, such as pictures, diagrams, flowcharts, demonstrations, videos.
	Verbal	Prefer to perceive materials in a verbal form, such as texts, audios.
Understanding	Sequential	Prefer to process information sequentially.
	Global	Prefer to grasp the whole picture first.

2.4.7.1. Format of the Index Learning Styles

To measure the learning style of the learners based on the FSLSM, Felder and Solomon developed the Index of Learning Styles (ILS). The ILS questionnaire consists of 44 items that are conveniently available on http://www.engr.ncsu.edu/learningstyles/ilsweb.html (Soloman & Felder, 2005). The questionnaire is in a multiple-choice form (with two options, "a" and "b") and designed to separate individuals with respect to learning style.

The FSLSM is organized in four dimensions, with each dimension represented by 11 questions (Van Zwanenberg, Wilkinson, & Anderson, 2000). Each item is designed to contribute to only one of the four scales. Question number 1 and for every 4 increments on it belong to the active-reflective dimension. Question numbers 2, 3, 4 and for every 4 additions refer to sensing-intuitive, visual-verbal, and sequential-global dimensions respectively.

Scoring for each dimension is between +11 and -11 with a step of +/-2. When answering a question, for instance in the active-reflective dimension, +1 is added to represent the first pole (active) and -1 is added to symbolize the second pole (reflective). The total score in each dimension is obtained by summing the scores from the first and second poles. The first pole consists of active, sensing, visual, and sequential learning, and the second pole comprises reflective, intuitive, verbal, and global learning. The final score is always exhibited in an odd number of 1, 3, 5, 7, 9, and 11 (see Figure 5), with scores 1 and 3 showing a balance along the dimension, score 5 and 7 representing a moderate preference for one pole of the dimension, and score 9 and 11 indicating a strong preference for one pole rather than it's opposite (Hawk & Shah, 2007).

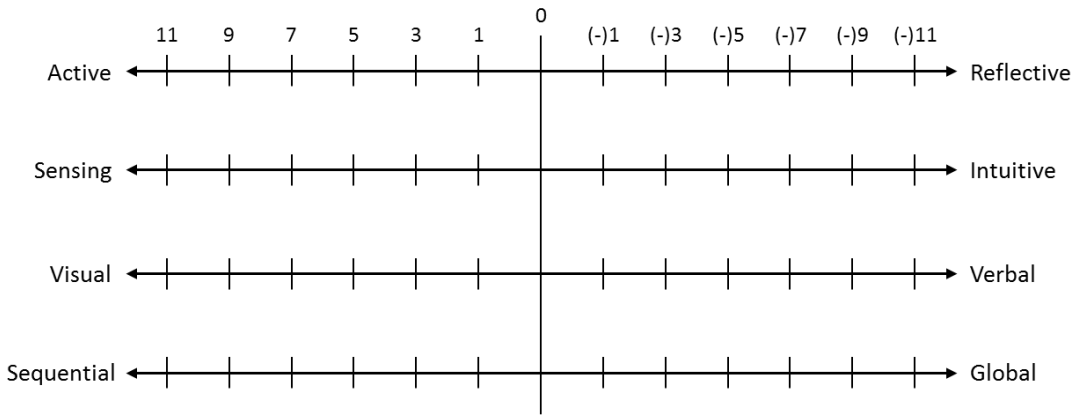


Figure 5. Felder-Silverman learning style model

2.4.7.2. Validity and Reliability of ILS

Felder and Spurlin (2005) conducted a comprehensive examination of the ILS, including its reliability and validity. Concerning the reliability test, the internal consistency reliability has been carried out with Cronbach's coefficient alpha as a criterion of acceptability. The finding showed that the alpha value for each dimension exceeded the criterion value of 0.5. This finding inlined with three other results from Livesay et al., (2002), Van Zwanenberg et al. (2000), and Zywno (2003) where the alpha value met the criteria, except one for the sequential-global dimension specified by Van Zwanenberg et al. (2000). Moreover, in terms of the test-retest reliability, the results from Livesay et al., (2002), Seery et al., (2003), and Zywno (2003) were also reported satisfactory.

Regarding the validity, Felder and Spurlin (2005) summarized from several studies that the ILS was indicated valid for both convergent and divergent construct validity test. It is also found that the ILS might be considered valid, and suitable instrument for assessing the student's learning style (Felder & Brent, 2005).

In addition, it is remarkable that many studies have been conducted for evaluating the reliability and validity of the ILS (Felkel & Gosky, 2012; Litzinger, Lee, & Wise, 2005; Litzinger, Lee, Wise, & Felder, 2007; Platsidou & Metallidou, 2009). Those studies found that the ILS seems reliable and valid to distinguish the preference of student's learning style, although some of which recommend continuing research on the instrument.

2.4.7.3. Sharing Concept with other Models

Each of the dimensions on the Felder-Silverman learning style model actually has a similar theoretical and terminology with other learning style models, although the combination of all dimensions yielded a unique characteristic. Some of major learning style models that shared the theoretical concept with the Felder and Silverman model are the Kolb model, the Dunn and Dunn model, the Myers-Briggs Type Indicator, the Honey & Mumford model, and VARK model.

As can be seen in Table 3, the active-reflective aspect of the Felder-Silverman model is identical with the same aspect on the Kolb model, and the impulsive and reflective of the Dunn and Dunn model. This dimension represents the way learners prefer to process the upcoming information. Active learners learn better through engagement in activities or discussions with peers, whereas reflective learners tend to absorb information through

introspection and work alone. The active and reflective learner types are also significantly related to the extravert and introvert of the Myers-Briggs Type Indicator, respectively. The Felder-Silverman and the Honey & Mumford model also share the learning style concept of action and reflection.

Table 3. Learning styles comparison

Modes	Kolb	Honey & Mumford	Felder & Silverman	MBTI	VARK	Dunn & Dunn
1	Active Reflective	Activist Reflector	Active Reflective	Extravert Introvert		Impulsive Reflective
2	Concrete Abstract	Pragmatist Theorist	Sensing Intuitive	Sensing Intuition		
3			Visual Verbal		Visual Aural Read/Write Kinesthetic	Visual Aural Time Kinesthetic
4			Sequential Global			Analytic Global
5						Sound Light Temperature Design
6						Motivation Persistence Responsibility Structure
7						Self Pair Peers Team with Teacher Mixed

The sensing-intuitive element of the Felder-Silverman model is equal to two aspects from the MBTI and may equivalent to the concrete-abstract dimension of the Kolb model and pragmatist-theorist of the Honey & Mumford model. This element refers to the most suitable type of information preferentially perceived by learners. Sensing learners like learning facts and need more practical cases, while intuitive learners prefer theories and innovation.

The Felder-Silverman, VARK, and Dunn and Dunn model share a common idea on the visual-verbal scope. This scope concerns the most effective channel for learners to perceive external information. Visual learners learn best from what they can see, such as images, graphics, diagrams, or flow charts, while verbal learners prefer to learn from what they have heard, read, or said.

The sequential-global aspect of the Felder-Silverman model is analogs to the analytic-global perspective on the Dunn and Dunn model. This aspect deals with the preferred way of structuring information in order to easy understandable by learners. Sequential learners prefer a linear and orderly explanation, while global learners prefer an initial overview and holistic thinking.

2.5. The Concept of Knowledge

The definition of knowledge is debated by many philosophers, practitioners, and educators. However, most of the definitions are derived from the classical definition from Plato and Aristotle. Plato and Aristotle were trying to answer the fundamental question: "What is knowledge?" In a simple manner, they may say that "knowledge is justified true belief" (Bolisani & Bratianu, 2018). This concept of knowledge is in line with the basic definition used by Hunt (2003) in his study to measure knowledge. Hunt defined knowledge as a belief that is true and justified (Hunt, 2003). Nonaka & Takeuchi (1995) is also adopted the traditional Plato's definition of knowledge in their theory of organizational knowledge creation. However, they argued that there is a significant difference in interpreting that definition. They assumed that the traditional one is more focused on the philosophical discussion, while the definition from them is rather focused on the managerial or organizational context.

From the definition mentioned above that generally satisfying by many researchers, it can be underlined that there are three key terms, i.e., true, belief, and justified. Neta & Pritchard (2009) called those three as a tripartite account of knowledge and made three basic conditions as follows:

- The truth condition: it refers to the condition in two different situations. If one knows a proposition, then that proposition must be true. It is valid for the opposite one if the proposition is not true, then that person does not know what he claims to know.

- The belief condition: it refers to the condition demands. If one knows a proposition, then he/she believes that proposition.
- The justification condition: it refers to the condition that requires a practical way to justify that the belief one has is true.

2.5.1. Bloom's Taxonomy

Bloom's taxonomy is a classification model commonly known as made by Bloom to classify educational learning objectives based upon its complexity. This taxonomy generally consists of three different domains, i.e., cognitive, affective, and psychomotor domain. The first two domains, cognitive and affective domains, were originally made by Bloom and his colleagues (Bloom, Engelhart, Furst, Hill, & Karthwohl, 1956; Krathwohl, Bloom, & Masia, 1964). Meanwhile, the psychomotor domain was created by other educators (Simpson, 1971).

The cognitive domain was published in 1956 by Bloom and his colleagues as a Handbook I of Taxonomy of Educational Objectives (Bloom et al., 1956). This domain refers to the knowledge-based domain that consists of six levels. The cognitive domain has been the primary focus of most traditional education and is frequently used to structure curriculum learning objectives, assessments, and activities.

The cognitive domain divided into two levels of category. The lowest three levels are knowledge, comprehension, and application. Meanwhile, the highest three levels are analysis, synthesis, and evaluation. This cognitive taxonomy is structured in a hierarchical model where the higher level also masters at its lower level. For instance, a student who has a capability at the "application" level has also competent at the "knowledge" and "comprehension" level. One can easily see the arrangement from lower- to higher-order thinking of learners. The followings are the cognitive levels and their short characteristics:

- Knowledge: it involves recognizing or recalling relevant knowledge without necessarily understanding what they mean.
- Comprehension: it involves demonstrating an understanding to organize, compare, translate, interpret, classify, and state the facts and ideas.
- Application: it involves applying acquired knowledge and techniques to solve problems.

- Analysis: it involves examining and breaking information into constituent parts, determining the relationship between one part to another and to an overall structure.
- Synthesis: it involves building a structure or pattern from diverse components or parts.
- Evaluation: it involves making judgments about information based on criteria and standards.

The original version of cognitive taxonomy withstands for decades, but then in 2001, there was a revision made by Anderson & Krathwohl (2001). Basically, there are minor terminology changes from noun to verb forms, yet it has actually quite significant differences. The two lowest levels of original taxonomy, "knowledge" and "comprehension" are renamed into "remembering" and "understanding," respectively. Then the two next levels are changed grammatically from noun to verb form, i.e., "application" to "applying" and "analysis" to "analyzing." And the top two levels are exchanged from the old to the new version (Forehand & others, 2005). "Evaluation" from the old version moved to the one position below and changed literally as "evaluating" and "synthesis" moved to the top spot in the new version as "creating". The comparison structure of the old and new version, including its changes, can be observed in detail in Figure 6.

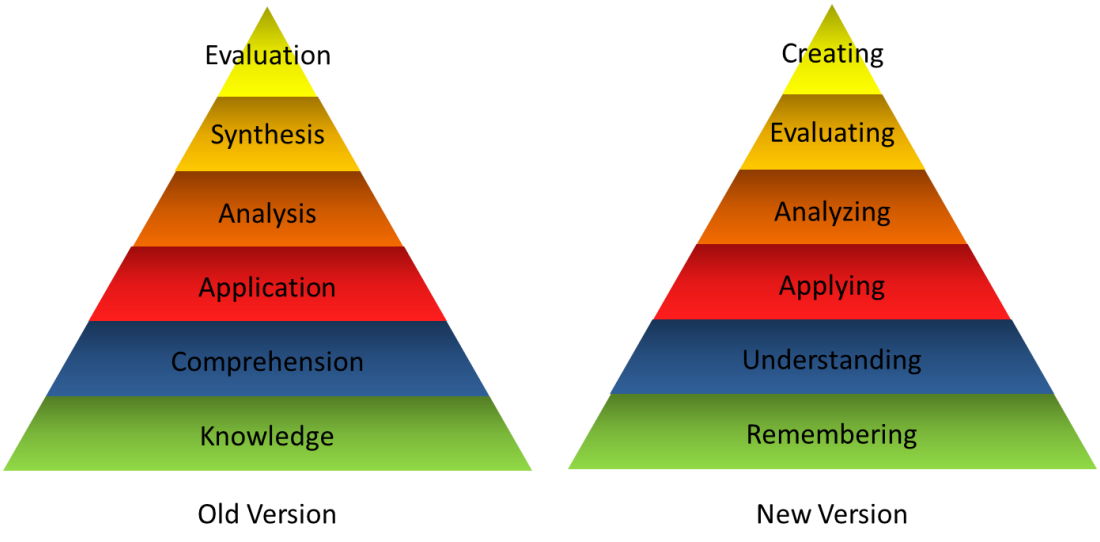


Figure 6. Terminology changes of Bloom's cognitive levels

The revised edition of Bloom's cognitive domain taxonomy comprises of remembering, understanding, applying, analyzing, evaluating, and creating. "Remembering" positioned at

the lowest level and ended by “creating” at the top level. Each level of the new edition of taxonomy is defined as follows:

- Remembering: it involves Recalling and retrieving previously learned information.
- Understanding: it involves comprehending the meaning, interpreting, and stating the problem in any words.
- Applying: it involves using a concept or acquired knowledge to execute the challenge.
- Analyzing: it involves separating material or concepts into parts and understanding how the parts relate to one another and to an overall structure.
- Evaluating: it involves making judgments about the values of ideas or materials based on a set of criteria.
- Creating: it involves building a structure or pattern from diverse elements by putting and reorganizing the respective elements.

In 1964, Krathwohl et al. (1964) were published the second volume of the Taxonomy of Educational Objectives (Handbook II). This publication specifically talked about the affective domain of Bloom’s taxonomy. The affective domain describes the way in which people deal with things emotionally, such as feelings, values, appreciation, enthusiasms, motivations, and attitudes. This domain refers to emotion-based behaviors in learning. There are five levels in the affective domain, starting from the lowest order processes to the highest, namely: receiving, responding, valuing, organizing, and characterizing.

The psychomotor domain was actually proposed by Simpson (1971). There was no direct involvement of Bloom in this domain. This domain describes the ability of people to the physical movement, coordination, and use of motoric areas. This domain refers to the action-based. This psychomotor domain consists of seven major categories listed from the simplest behavior to the most complex: perception (awareness), set, guided response, mechanism (basic proficiency), complex overt response (expert), adaptation, and origination.

2.5.2. Knowledge Measurement

As mentioned above that there are three key factors in the definition of knowledge, namely true, belief, and justified. Those three factors are bounded into one. Therefore, being correct or true is not enough. To be called knowledge, it cannot be only said that the belief

is correct, but it should be justified. Hunt (2003) suggested a set of rules to measure a person's level of knowledge. The set of rules can be defined as a number as well as the formula to count the number. The test whether a subjective or objective model can be considered as a "set of rules" and the score from the test's result is the manifestation of one's knowledge level.

The subjective test deals with the evaluation process by giving the opinion. Meanwhile, an objective test refers to the evaluation that has right or wrong answers and consequently can be easily marked objectively. The subjective test may more valid for measuring the person's knowledge comprehensively, but this test is more challenging in the grading process since there is subjectivity involved. In the meantime, the objective test is offering many advantages, which include objectivity, ease, economy, and reliability. Some of the common objective test techniques are multiple-choice, true/false, matching, and ordering.

Hunt (2003) utilized a multiple-choice test with additional function for recognizing the person's knowledge. Meanwhile, in the context of technology-enhanced learning, much research has used a multiple-choice test to measure the level of knowledge. The authors (Mampadi, Chen, Ghinea, & Chen, 2011) used a pre-test and post-test to measure knowledge level. The pre- and post-test consisted of several multiple-choice questions with five possible answers. Lazarinis, Green, & Pearson (2010) used various types of tests, not only multiple-choice model tests but true/false and order model tests, to measure knowledge level.

To measure a person's knowledge on a certain topic, the test items must represent the topic itself. It means that the construction of test items should be followed the learning objectives. In the old version of Bloom's cognitive domain, which refers to the knowledge-based domain, there are six levels, including knowledge as the lowest until evaluation as the top level. The study from Esiobu & Soyibo (1995) suggested that to measure student's understanding of science concepts; the test should be constructed beyond the comprehension level on Bloom's taxonomy. Thompson & Soyibo (2002) were also tested the student's understanding by considering the three lowest levels of Bloom: knowledge, comprehension, and application level. However, it should be noticed that how high the cognitive level to be measured is highly dependent on the learning objectives itself. It is also considering the student's education level; the cognitive level achieved on the level of primary school must be different from the one on the secondary school, for instance.

2.6. E-Learning Evaluation

The development of e-learning system is one of the most rapidly growing areas of education and training. Hence, it is important to ensure the e-learning system could positively usable and meet the user's demand. To this point, it requires an assessment or evaluation to determine whether the e-learning application is usable, functional, and acceptable 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).

- Software testing: It is a common thing to develop the e-learning system by involving a software engineering approach. In this respect, one essential stage to be considered is to ensure that the e-learning system may work functionally without any errors. Some of the software's errors that commonly revealed in the coding stage are classified into three: 1) syntax errors, 2) run-time errors, and 3) logical errors (Jogiyanto, 2005). All of these mentioned errors should be eliminated before continuing to software testing. Pressman (2005) divided the software testing into two different methods: black-box testing and white-box testing. Luo (2001) defined the black-box testing as functional testing. The functional test focuses only on the outputs generated by the system with specific inputs as determines in the system's specifications. This test ignores the detailed mechanism in the internal structure of a system (IEEE, 1990). Meanwhile, Luo (2001) stated that white-box testing is structural testing. According to IEEE (1990), the structural test takes into account the internal mechanism of a system. Williams (2006) implied that one basic test that should be conducted for software testing is black-box testing (functional-based test).
- Expert review: In the e-learning system, there is a strong interaction between a system (usually installed on the computer) and human (as a user). This circumstance is generally known under the name Human-Computer Interaction (HCI). In the HCI, one important thing to consider is the user interface. The user interface is an interface to bridge the interaction or communication between the computer system and the user. Nielsen & Molich (1990) mentioned that one basic way to evaluate the user interface is heuristically by simply looking at the interface and then passing judgment according to one's own opinion. The one who entitled to give the evaluation should have the expertise to the object of assessment. This

kind of evaluation can be defined as an expert-based evaluation. In principle, it is possible to use one single expert evaluator to perform a heuristic evaluation of a user interface. However, it is practically difficult to dig a comprehensive usability problem. The finding from many different projects indicated the relatively poor results from the single inspector. In contrast, the involvement of more evaluators can find more usability problems. Nielsen (1995) recommended about five evaluators, but certainly at least three. However, to get a higher ratio of benefits to costs, he suggested four as the optimal number of evaluators.

- End-user evaluation: Since there is user participation on the e-learning application, Dix et al. (2004) suggested to consider not only the expert evaluator but also the actual user tester. The user participation in the evaluation tends to occur in the later stages of development just after the system prototype to some extent passed the software-based and expert-based evaluation. This evaluation aims to know the acceptability level of users to the system. It is also to find the level of usability of the intended system from the user's perspective. This kind of evaluation may be conducted in a controlled laboratory setting or actual field environment (Dix et al., 2004). Dix et al. (2004) also recommended a controlled experiment as one of the most powerful methods of evaluating the design aspect. In this controlled experiment, the basic form of, i.e., hypothesis, variables, and statistic measurement should be considered.

2.6.1. Usability Evaluation

In e-learning applications, usability is an essential key issue that refers to the interaction of users with a system (Parlangeli, Marchigiani, & Bagnara, 1999). It is often used to measure the easiness level of the e-learning program and the satisfaction level of the user to the system. The definition of usability was postulated by researchers in many different meanings. However, there are many studies of usability that refers to the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).

As defined by the ISO 9241-11, usability is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO, 1998). This standard provides guidance on usability that related to the ergonomic standards. Meanwhile, ISO/IEC 9126-1 described the usability as

"the capability of the software product to be understood, learned, used, and attractive to the user, when used under specified conditions" (ISO, 2000). The phrase "when used under specified conditions" in ISO/IEC 9126-1 is equivalent to "in a specified context of use" in ISO 9241-11. This phrase means that usability is only referred to the capability of products or systems to be used in a specific context. Different standard made by computer society in the context of software engineering, the Institute of Electrical and Electronics Engineers (IEEE Std 610.12-1990), defined usability as "the ease with which a user can learn to operate, prepares inputs for, and interprets outputs of a system or component" (IEEE, 1990).

Other than that, there are some other definitions of usability that often used as references. One of the widely known definitions is from Nielsen (1994). He mentioned that usability comprises not a single component but multiple, namely learnability, efficiency, memorability, errors, and satisfaction. Learnability refers to the ease to learn the content offered by the program, while efficiency talks about the efficient level to use the program. Memorability focuses on the ease to remember the way to operate the application, and the error component means that the system should free from errors or at least have a low error rate. Meanwhile, satisfaction discusses the level of satisfaction rated by users.

From some definitions of usability mentioned previously, it can be underlined that usability evaluation is concerned with gathering information about the usability of the system to assess it by collecting the user's perspectives. It can be conducted 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, 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.

2.6.2. Overview of Usability Evaluation Methods

There are a number of methods and questionnaires that have been used for evaluating or assessing the usability of technological products based on 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 on 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 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 a 5-point 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), 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.

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 be easily understood by respondents (Lund, 2001). Consequently, the questionnaire can be used with little training. 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 the use or tabulation fees. It is also essential to consider that the respondents sometimes become bored and lack of 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).

The USE has been used to evaluate the usability of systems or applications in varying domains. Table 4 briefly describes the variety of research domains assessed using the USE questionnaire. It is interesting to note that the USE has been used in many investigations to evaluate hardware or software products. Arm-hand training equipment is an example of a hardware system. Meanwhile, the majority research domain listed in Table 4 is related to the software application. It is also found that the USE has been implemented to measure usability in multimedia-based research, i.e., related to videos, movies, MP3 Player, and virtual/augmented reality. Table 4 also shows that the USE is becoming common to assess the usability in the education and training fields.

Table 4. Research domain evaluated using USE questionnaire

No.	Research's Domain	References
1	Arm-hand training equipment	(Timmermans et al., 2010; Vanmulken, Spooren, Bongers, & Seelen, 2015)
2	Personal health records	(Peters et al., 2009; T. Wang & Dolezel, 2016)
3	Prevention application	(Barrio, Ortega, Bona, & Gual, 2016; Patwardhan et al., 2015)
4	Virtual/augmented reality	(Albertazzi, Okimoto, & Ferreira, 2012; A. F. M. Hashim, Hussin, Othman, & Ahmad, 2016; Tsiatsos, Douka, Zimmer, & Geoffroy, 2014)
5	Clinical prediction rules tool	(Zarabzadeh et al., 2016)

6	Video and map navigation	(Noronha, Álvares, & Chambel, 2012)
7	Videos and movies cloud	(Gil et al., 2012)
8	Social networking sites	(Chun & Katuk, 2014; Rivera, Davis, Mouloua, & Alberti, 2010; Salameh, 2017)
9	E-learning environment	(E. W. Black, Ferdig, & DiPietro, 2008; Hattink et al., 2015; Jeong Kim, Pederson, & Baldwin, 2012)
10	Interactive learning tool	(Campos & Harrison, 2009)
11	Ontology visualization	(Fu, Noy, & Storey, 2013)
12	Mobile application	(Kratz, Westermann, Rohs, & Essl, 2011)
13	Educational system	(Faria et al., 2016; Huang, Liang, & Chiu, 2013; Huang, Liang, Su, & Chen, 2012; Hung & Young, 2015)
14	MP3 Player	(Wallace & Yu, 2009)
15	Telepresence application	(Kiselev & Loutfi, 2012)
16	Online counseling system	(W. N. W. Hashim, Othman, Syafiq, & others, 2013)

2.6.3. Validity and Reliability of USE Questionnaire

Two essential criteria in any kind of psychometric tool are the validity and reliability of the instruments. Validity refers to the extent to which the measurement tool can measure what it is intended to measure. Meanwhile, reliability talks about the consistency of the measurement tool to measure over a period of time. In the development stage of this USE questionnaire, Lund (2001) reported the very high level of Cronbach's Alpha. As time goes by, there are many researchers and practitioners who employed this questionnaire found similar findings as Lund had in terms of the USE validity and reliability.

Gao, Kortum, & Oswald (2018) conducted a psychometric evaluation of the USE questionnaire and found that the survey tool was valid and reliable to measure usability. Similarly, Dantas et al. (2017) conducted validation of the Portuguese version of USE indicated that the questionnaire has excellent internal consistency and inter-rater reliability. The finding also confirmed that the modified version of USE has construct validity. Consistent with others, the internal consistency and reliability of the Chinese translation of USE questionnaire were good either for each aspect of measurement or for the overall score (Huang et al., 2012). Some other studies related to online personal health records (Peters et al., 2009), culture-oriented usability (Wallace, Reid, Clinciu, & Kang, 2013; Wallace & Yu, 2009), e-book learning system (Huang et al., 2013), e-readers (Hung & Young, 2015), mobile prevention applications (Patwardhan et al., 2015), virtual reality system

(Hashim et al., 2016), and social networking sites (Chun & Katuk, 2014; Salameh, 2017) also reported that the validity and alpha reliability were considered acceptable.

2.7. Research Hypotheses

The research hypothesis reflects a preliminary supposition of the result of the current study. This aims to interpret certain phenomena and to provide guidance for further investigation. A hypothesis could be scientifically proven right or wrong. In this study, one of the main objectives is to determine whether the utilizing of the adaptive e-learning system in the learning process may improve the learning achievement compared with the traditional learning setting. According to the previous research's findings, the following research hypotheses are proposed:

- **H_1:** There is no statistically significant difference between the experimental group and control group in terms of the pre-test score of the total achievement.
- **H_2:** There is a statistically significant difference between the experimental group and control group in terms of the post-test score of the total achievement.
- **H_3:** There is a statistically significant difference between the pre-test and post-test within the experimental group in terms of the mean score of the total achievement.
- **H_4:** There is a statistically significant difference between the pre-test and post-test within the control group in terms of the mean score of the total achievement.
- **H_5:** There is a statistically significant difference between the experimental group and control group in terms of the gain score of the total achievement.

Another objective of the current study is to investigate the factors that might affect student satisfaction on the use of the adaptive e-learning system in the learning process. It also explores the relationship amongst variables associated with the usability. The research hypotheses are proposed as follows:

- **H_6:** The independent variables (usefulness, ease of use, and ease of learning) all together are statistically significant influence the dependent variable (satisfaction).
- **H_7:** Usefulness is statistically significant influence satisfaction.
- **H_8:** Ease of Use is statistically significant influence satisfaction.
- **H_9:** Ease of Learning is statistically significant influence satisfaction.

2.8. Summary

Education in Indonesia has a huge challenge to provide good education equality for all Indonesian pupils with its diversity of culture, ethnic, religious, and linguistic. On the way for that, Indonesia obligates 12 years of compulsory education. The mandatory education comprises of six years of primary school, followed by three years of junior secondary school and three years of senior secondary school. Generally, the senior secondary school divides into two tracks, i.e., general and vocational school. At this point, the government sets the 70:30 for the ratio of vocational and general secondary school to be achieved in 2025. This high proportion of vocational path aims to prepare the prospective skillful workers for fulfilling all industrial sectors. The government uses many strategies in which one of them by providing significant investments and resources in the information and communication technology sector.

The utilization of technology in education is becoming more and more important. The technology may increase the effectiveness and efficiency in delivering the information. One of the popular approaches often studied recently is personalized e-learning. This e-learning strategy may provide an individual environment that fits with each personal preference. The more the students feel comfortable with the instructional system, the more they could comprehend the learning material. The personalized e-learning may involve learning style, cognitive level, initial knowledge, or learning behavior as the adaptive variables. The decision to choose one or more variables for adaptivity, including its combination, will be a crucial part to provide the most suitable e-learning. Nevertheless, many studies found that multiple criteria on adaptivity brought to a positive outcome. Therefore, this current study considers the widely used learning style for technical education, Felder and Silverman learning style model, and the initial knowledge of students for the personalization criteria.

In all products or systems, including the technological-based education system, usability is an essential issue to evaluate the interaction of users with a system. Many definitions and questionnaires have been proposed by practitioners and researchers. Nevertheless, all of them lead to satisfaction measurement. The one which is providing many advantages is the USE Questionnaire. The USE comprises ease of use, ease of learning, usefulness, and satisfaction dimensions, which is proved considerable valid and reliable.

3
RESEARCH METHOD AND PROCEDURES

3.1. Introduction

This chapter describes the methodology and procedures used in this study in order to address the research problems. There are two research steps, the first one focuses on the design and development process of the adaptive e-learning system, and the second one discusses an experimental study that applies the adaptive e-learning system for the learning process.

The first step, the development of the adaptive e-learning system, is conducted by using an Instructional System Design (ISD), which typically used for the development of an educational system. There are many ISD models which are valid for any education system design. One of the prevailing models of the instructional system design is ADDIE (Analysis, Design, Development, Implementation, and Evaluation (Dick, Carey, & Carey, 2005). Since the e-learning system is strongly related to the development of software, thus the process is also considering the software engineering model as well. The linear sequential model is often used in software development, which generally consists of analysis, design, coding, testing, and support (Pressman, 2005). Accordingly, the design and development of the adaptive e-learning system in this study is based on the ADDIE and considering the linear sequential software development model.

The second step, the experimental study, begins with the selection of a suitable research design considering the phenomenon that revealed. Then, the strategy is continued to select the sample as a representative of the larger set of population. Next, the construction of the instruments is presented. Afterward, the procedures conducted in the experimental research, including data collection and analysis, are illustrated. It also considers the ethical issues which are important in educational research.

3.2. Instructional System Design

The instructional system design is the systematic approach for designing and developing instructional courses or material, both in the physical old-school instructional era and in the modern digital era. Many instructional design models have been developed by researchers. One of the widely accepted models is the generic “analysis, design, develop, implement, and evaluate” model or generally called an ADDIE model (Allen, 2006).

The research conducted by Molenda (2003) found that there was no clear information about the source for the ADDIE model. ADDIE existed more as a label than as an actual model. Many people recognized ADDIE is an acronym for the Analysis, Design, Development, Implementation, and Evaluation phases of the Instructional Design process (Lohr, 1998). Nevertheless, according to the investigation conducted by Molenda (2003), the underlying concept of the ADDIE model was firstly created by the Center for Educational Technology at Florida State University for the U.S. Army in 1975. The document provides a graphic overview of the Interservice Procedures for Instructional Systems Development (IPISD), which shows five phases: analyze, design, develop, implement, and control (ADDIC) (Branson, 1978).

Nowadays, the networked-education system has quickly become widespread and accepted amongst institutions throughout the world. Shelton & Saltsman (2011) summarized that the ADDIE instructional model provides an essential path for developing and teaching an online course. Passerini & Granger (2000) added that technology-supported instruction has a similar system development life cycle with software development. Moreover, the ADDIE model is more-less similar to the Linear Sequential Model, as mentioned by Pressman (2005). The Linear Sequential Model sometimes called the classic life cycle or the waterfall model. The linear sequential model suggests a systematic, sequential approach to software development through analysis, design, coding, testing, and support (Pressman, 2005). By considering some theories above, therefore, the development of the adaptive e-learning system in this study did not only focus on the perspective of instructional design but also contemplated with the software development aspects.

The procedure, as shown in Figure 7, describes each phase of the development of an adaptive e-learning system in more detail.

Figure 7. The ADDIE Model

3.2.1. First Phase: Analysis

The analysis phase is an important step and as a valuable foundation for all other stages of the instructional system design. This phase will be collecting the necessary information regarding the three following segments: analysis of the learners, analysis of the course, and analysis of the online delivery medium (Shelton & Saltsman, 2011). All of the information collected in this phase will be used as the building blocks for the design and development activities.

3.2.1.1. Analysis of the Learners

Analysis of the learners is the process of digging the key information focused on the user. In this segment, the most important information was collected based on the suitable learner's preference. The pre-research has been conducted by collecting the data about the students' learning styles through a questionnaire (Hariyanto & Köhler, 2017b). The collected data can be used to map the learning style of the students. It can also be used as initial guidance for the instructional developer to design learning strategies and resources that address the student's needs.

To perform the survey, a paper-based questionnaire was given to 32 students enrolled in the Department of Computer Network Technique of SMK 2 Pengasih, Kulonprogo in March 2016, at the end of one particular course meeting. The survey instrument is the ILS (Index of Learning Style) created by Soloman and Felder (2005), which is conveniently available online at http://www.engr.ncsu.edu/learningstyles/ilsweb.html. Since the participants in

this survey are Indonesian students, the original English ILS was translated into Indonesian by an official translator from the language center of Yogyakarta State University. The result was then compiled into a final version that took certain aspects of meaning and understanding into consideration.

The data collection processes involved the teacher by distributing the questionnaires to the students roughly 20 minutes before the seminar ended. Prior to its circulation, a brief explanation of the survey's purpose and instructions for filling it out was given to the students. Accordingly, each student took approximately 10 minutes to complete the questionnaire.

Concerning the validity and reliability of ILS, Felder & Spurlin (2005) may consider the ILS as a reliable, valid, and suitable instrument for assessing a student's learning style. Notably, many studies have evaluated the reliability and validity of the ILS (Felder & Brent, 2005; Felkel & Gosky, 2012; Litzinger et al., 2005, 2007; Platsidou & Metallidou, 2009). Many of them have recommended the use of the instrument because it offers a dependable and effective method to distinguish an individual's learning style.

Table 5. Learning style preferences

Active (%)	Reflective (%)	Sensing (%)	Intuitive (%)	Visual (%)	Verbal (%)	Sequential (%)	Global (%)
75.00	25.00	68.75	31.25	81.25	18.75	65.62	34.38

The surveys reported that 18 male students and 14 females have participated in this survey. The mean score of the results was shown in Table 5; one can notice that the students involved in this survey preferred the active, sensing, visual, and sequential learning styles. This outcome corroborates ILS response data tabulated by Felder and Spurlin (2005) from several engineering institutions located in various countries (Brazil, Canada, Ireland, Jamaica, the United Kingdom, and the United States). Similarly, this study's results are also consistent with research findings collected by Lee & Sidhu (2015) at other engineering institutions in Mexico, New Zealand, China, and Malaysia. The findings could be used as a beneficial recommendation for the next design phase to get an appropriate blueprint that suitable for the student's needs.

3.2.1.2. Analysis of the Courses

Analysis of the courses performed, including its goal and learning objectives. In this segment, the course developer must review the goal of the course, the learning objectives of the course, and the relation between other courses and the entire program curriculums. Since the online courses have the same typical curriculum with the existing courses which are being created for a new medium, the course goals and learning objectives are existed already and may not need some modification.

To address this analysis, the initial process to analyze the course begins with the selection of the subject by considering some aspects, namely: the school academic calendar, the curriculum of Computer Network Techniques department, the availability of students who want to participate, and the willingness of the teacher who will conveniently join this study. Therefore, the selection of the subject was discussed by the researcher, the head of the Computer Network Techniques department of SMK 2 Pengasih, and two subject-related teachers. As a result, the group discussion decided a Digital Simulation as a subject in this experiment.

The group discussion was continued to determine which Unit and Sub-Unit were suitable to the students promptly. To overcome this step, the course outline and the digital simulation handbook were analyzed. After that, the subject of digital simulation was organized and structured into a unit and sub-unit. Three units in Digital Simulation subject were applied in the e-learning system, namely “Pembelajaran Kelas Maya” (Online Class Learning), “Tahap Pra-Produksi Video” (Video Pre-production Stage), and “Tahap Produksi Video” (Video Production Stage). The detailed structure of the unit and sub-unit of Digital Simulation subject were shown in Figure 8.

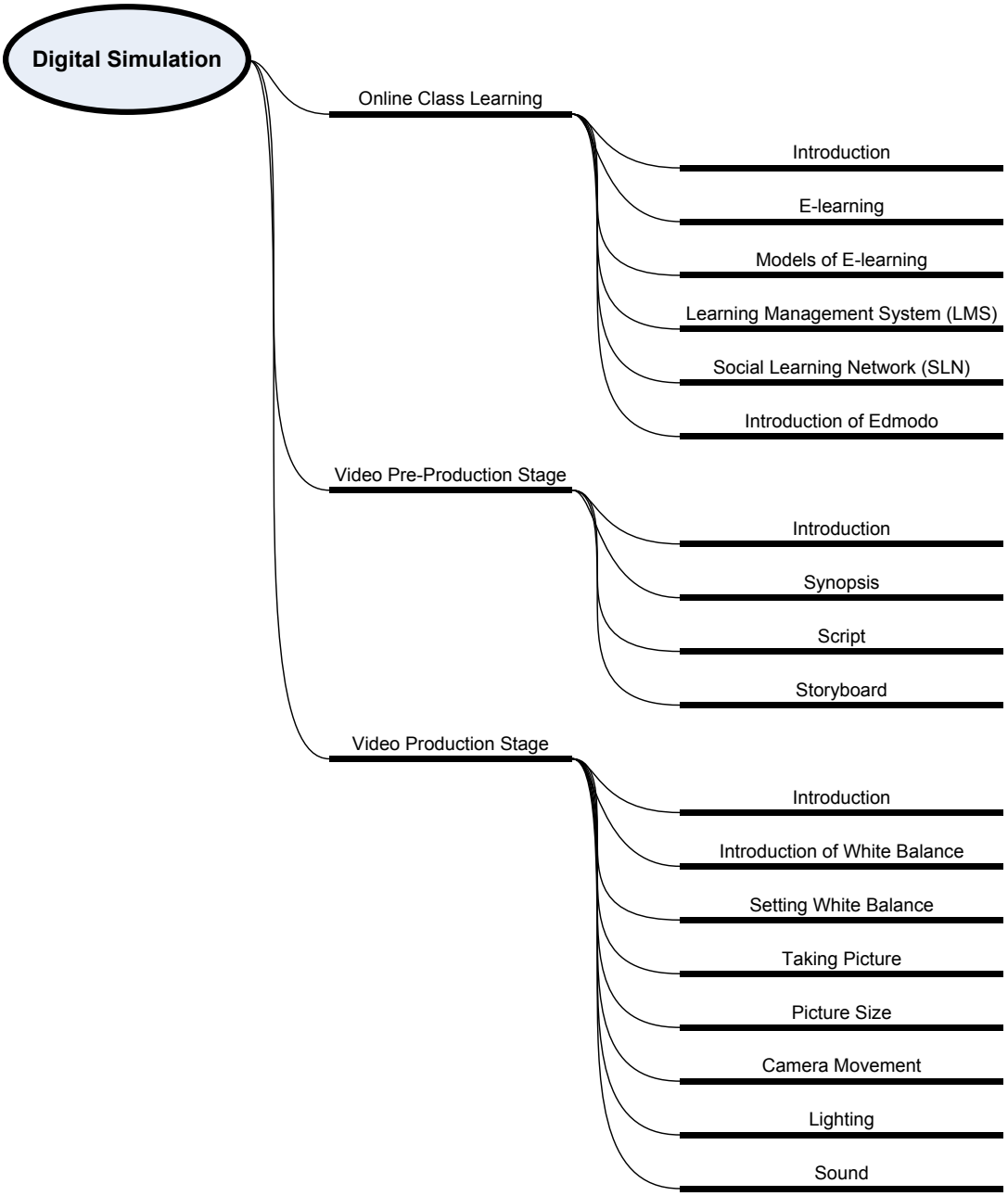


Figure 8. Structure of unit and sub-unit

3.2.1.3. Analysis of the Online Delivery Medium

Analysis of the online delivery medium focused on the process of analyzing the suitable technology used to deliver the course material from the system to the user. In this segment, the course creator must also consider the existing network infrastructure and the specification of computers used in online learning.

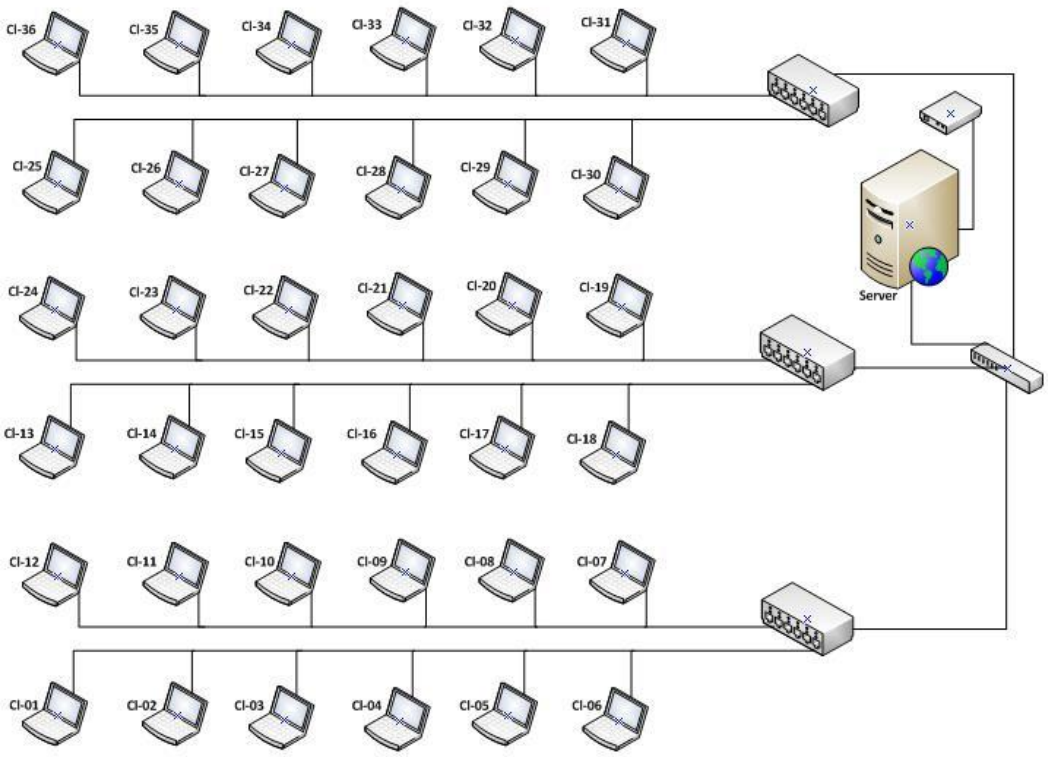


Figure 9. Computer network infrastructure

To evaluate the computer network infrastructure, the survey to the computer laboratory and the interview to the head of the department of Computer Network Techniques of SMK 2 Pengasih have been conducted. This department has three computer laboratories which have a good network connection. The computer laboratory used in this study, as seen in Figure 9, has a high-performance desktop-based computer server and 36 laptop-based computer clients. All of the computers are connected to a high-speed network cable CAT 6, which can transfer data up to 10 Gbps.

The network configuration used in this laboratory is typically known as a star network configuration, which is one of the most common models that has a robust capability for transferring data. In a star network, every node (computer) is individually connected to a central connection point (hub or switch) (Roberts & Wessler, 1970). This configuration is particularly beneficial as it does not affect the other nodes during a line failure in one node (Stallings, 2005).

For computer networking, the best model to deal with programming is web-based programming. It allows keeping the main program in the computer server, and the users can access it individually in each client using a web browser. With the specification of high-

performance processor Intel i7 in the computer server and computer clients of this laboratory, the computer network infrastructure can smoothly deliver the web-based learning material.

Concerning the technology used for the adaptive e-learning system, the main requirement for the programming language that should be taken into account is the ability to handle many users at one time properly. The best possible candidate to accommodate that situation is web-based programming software. A web-based application is any program that can be easily accessed over a network connection using the HTTP protocol. A web-based application is commonly installed in a computer server; meanwhile, the users can access it on the internet browser of the individual computer, which connected to either a cable or Wi-Fi network connection. One of the latest newcomer web-based programming, which has been getting popular recently is Laravel (Saunier, 2014:7). Laravel is a free distributed and open-source PHP web framework created by Taylor Otwell (Rees, 2012). Olanrewaju et al. (2015) evaluated the performance of four common PHP frameworks, including CodeIgniter (CI), Symfony, CakePHP, and Laravel, and found that Laravel has a higher performance over other frameworks. Laravel has a modular packaging system with model-view-controller (MVC) architecture (Bean, 2015:1). Laravel is the most commonly used for web-based development and supports the data exchange with popular databases, such as PostgreSQL, SQLite, MySQL, and SQL Server (McCool, 2012:3). Due to the advantages, Laravel is chosen for the development of the instructional system in this study.

3.2.2. Second Phase: Design

The design phase uses the output from the analysis phase to make a detail plan and strategy for developing the instructional system. The output managed by the design phase will be used as input for the next phase, the development phase. The design phase organizes strategies and goals identified in the analysis phase. In the term of the technical aspect, the design phase can be called as a blueprint or a plan of construction that guides the course developer toward the intended outcome.

3.2.2.1. The Adaptive E-learning Architecture Model

The main characteristic of an adaptive e-learning system is the provision of an ideal system according to the student's preferred style and knowledge state. Our proposed model has an architectural structure, as shown in Figure 10.

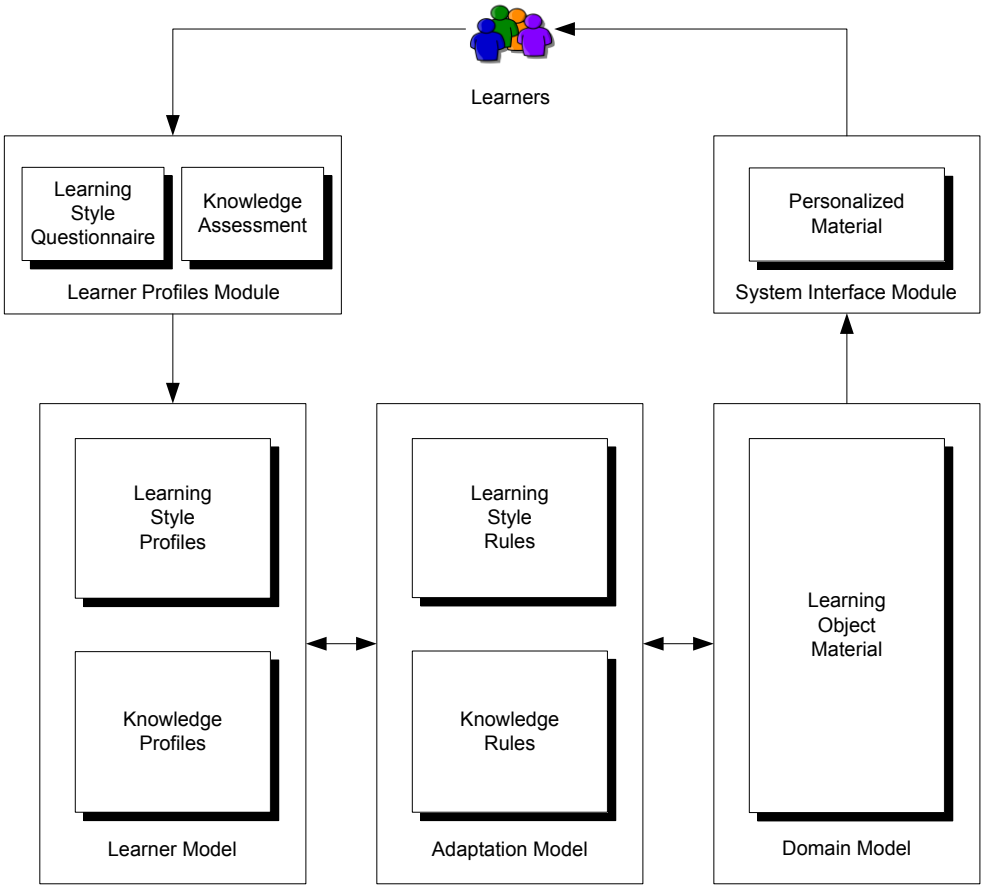


Figure 10. The proposed architecture model

The architecture is adopted from the Adaptive Hypermedia System, which consists of three basic components: the Learner Model, the Adaptation Model, and the Domain Model (De Bra et al., 2003), and two additional modules: the Learner Profiles Module and System Interface Module. These five components interact with each other to adapt to different aspects of the learning process (Hariyanto & Köhler, 2016).

The learner profiles module deals with the registration and login process. It consists of two separate functions which identify the learning preferences of the students based on a questionnaire, and the initial knowledge of the students according to a multiple-choice assessment. The learning style used in this system is chosen from the four dimensions of the Felder-Silverman approach.

Based on the collected student's responses, the Learner Model will score the student regarding his learner style and knowledge level. The results from the questionnaire and the pre-test score will be stored in the learner profile. The student's profile from the Learner Model is transferred to the adaptive engine and serves as the initial input for the

Adaptation Model to provide a suitable environment and material for the learner. The adaptive engine will provide the learning path according to the learner's preferences and level of knowledge. The adaptive engine will also control the navigation support and the presentation of the learning materials.

The Domain Model is used to store learning resources. It consists of the learning objects that support the students in learning activities. The Domain Model should have the ability to deliver particular material to the learner based on the command rules from the Adaptation Model. The System Interface Module will compile and translate the learning object material into a learning environment that is suitable for the student's preferences.

3.2.2.2. The Concept of Adaptation

There are many theories that explained the concept of adaptation. In the context of technology-enhanced education, Brusilovsky (1996) mentioned that the critical question while discussing any adaptive system is what can be adapted. To address that question, he divided the adaptation technology into two different classes, which are related to the presented content (content-level adaptation) and the link between pages (link-level adaptation). He referred to these classes of adaptation as an adaptation in presentation and adaptation in navigation support, respectively.

The idea of the adaptation in a presentation is the ability of the system to present the content adaptively based on student preferences. Since there are some different student preferences in one group of e-learning, the system should be able to provide the same information in different ways. Various techniques have been used by Hariyanto & Köhler (2017a) to accomplish the goal:

- Media type based: This is related to the visual-verbal dimension of the Felder-Silverman's Index Learning Style. The students may receive the information in two different ways: in visual format (pictures, diagrams, flowcharts, videos), or in verbal form (text, audio).
- Learning object-based: This is related to the active-reflective and sensing-intuitive dimension of the Felder-Silverman's Index Learning Style. The provided information could be made in different learning objects: in the form of "example" or "case study" format object.

The idea of the adaptation in navigation support is to provide a suitable learning path in the learning system that meets the student's preferences. Several interesting techniques have been suggested and implemented to deal with the technical aspects of "links" manipulation. To enable the navigation components to personalize the learning, the methods of direct guidance, link sorting, link hiding, link annotation, and map annotation can be used (Brusilovsky, 2004, 2007).

3.2.2.3. Flowchart of E-learning System

This chapter describes the e-learning flowchart to understand the workflow process when the student interacts with the e-learning system. A flowchart is a type of diagram to represent a process using different simple geometric diagrams (Chapin, 2003). A flowchart in the context of computer science typically has the following types of symbols (Wang et al., 2010):

- Oval/Rounded Rectangle: Represents the beginning and end of a program.
- Rectangle: Indicates a process of an activity or step.
- Diamond: Shows a conditional operation that determines the paths to be chosen, such as Yes/No or True/False.
- Parallelogram: Represents the process of an input or output data.
- Arrow line: Shows the flow of control from one step to another.

As depicted in Figure 11, the first interface of the adaptive e-learning system is the login page. Users are asked to log in to the system by providing their login information. If the login process fails, they can repeat the login process using their correct login information, or ask the system admin for the technical support.

After the login process, learners should take the ILS (Index of Learning Styles) Questionnaire based on the Felder and Silverman approach and answer the questions to investigate their preferences. The questionnaire allows one to be distinguished based on four dimensions of the Felder-Silverman learning styles. The data of a student's learning styles will be kept in the database.

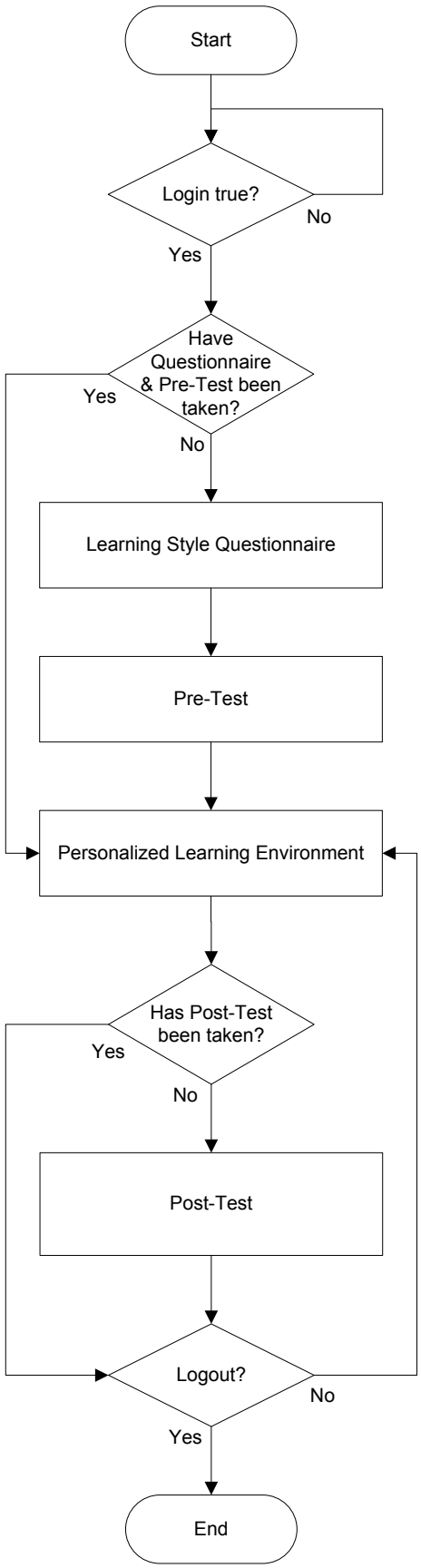


Figure 11. The flowchart of the e-learning system

The next step is the pre-test to assess the learner's level of knowledge. The pre-test is constructed in multiple-choice questions format. Since the course is structurally organized into several units, a set of standard questions is prepared to assess the learner's knowledge level for each unit. After the termination of the exam, the system determines the true and false answers and record it in the database.

After completing the identification of learner's personalization, the system provides the learning material according to the learner's learning style and level of knowledge. The results of the learning style questionnaire will be used by the system as a variable to change the navigation procedures and the environment mode adaptively. Furthermore, the results of the pre-test will command the system to decide which material will be displayed in the e-learning environment.

At the end of the course, when students are considered to have learned 100% of the planned material, students will take the post-test by answering multiple-choice questions. The score of the post-test is determined automatically by the system and is recorded in the database. In the last step, the students were advised to log out from the learning session.

3.2.2.4. Set of Rules

The essential process that should be taken into account in the design of the adaptive user interface for e-learning system is defining a set of rules. The set of rules is the group of rules to guide the designer to select the learning environment. These rules also determine the more appropriate or relevant learning resources for a particular learning style. Since the research used the learning style theory of Felder-Silverman, the development of the set of rules is based on the theoretical descriptions of Felder-Silverman learning styles and some previously conducted practical studies (Carmona, Castillo, & Millán, 2007; Carver et al., 1999; Dung & Florea, 2013; Franzoni, Assar, Defude, & Rojas, 2008; Hariyanto & Köhler, 2017a). The set of rules can be seen in Table 6, Table 7, and Table 8. Table 6 and Table 7 are the set of rules which represent the adaptation in presentation, while Table 8 is the rule to perform the adaptation in navigation support.

Table 6. Learning objects in the Active-Reflective and Sensing-Intuitive dimensions

Learning Objects	Active	Reflective	Sensing	Intuitive
Simulation	√		√	
Example	√		√	
Synthesis	√			√
Lesson Objective		√		√
Case Study		√		√

Table 6 lists the objects used in the learning environment related to the learning object-based adaptation method. The learning objects associated with two dimensions of Felder-Silverman are active-reflective and sensing-intuitive dimensions. There are five learning objects (simulation, example, synthesis, lesson objective, and case study) that correspond to those dimensions.

Table 7. Learning media formats in the Visual-Verbal dimension

Learning Media Formats	Visual	Verbal
Text		√
Image	√	
Audio		√
Video	√	√
Animation	√	

Table 7 describes the media utilized in the learning environment based on the learning media type-based adaptation method. The learning media formats are associated with the visual-verbal dimension. Visual preference is represented by image, video, and animation media, while verbal preference is represented by text, audio, and video formats.

Table 8. Learning path navigation in the Sequential-Global dimension

Learning Path Navigation	Sequential	Global
Direct Guidance	√	
Link Hiding		√

Table 8 shows the learning path navigation used to regulate the sequential-global dimension. At this point, the technique of adaptation in navigation support is used to

determine the appropriate learning path in the system. Since the sequential learner prefers to learn by orderly thinking or step-by-step learning, a suitable way to present the navigation is by using the direct guidance method which provides a link or button to explore the learning environment. The student can navigate one step forward to the next page using the “next” button or jump to the previous page using the “back” button. To deal with global learners, the link hiding method is used to give the ability to show or hide the link or button in the navigation components.

As mentioned in the chapter of the architecture model, two parameters for the e-learning system namely the student’s learning style and initial knowledge level were used to automatically change its learning environment. Previously, the set of rules related to the information about the learning style obtained by Felder-Silverman’s questionnaire has been illustrated. From now on, how the attribute of knowledge level should be ruled will be explained.

The data of knowledge level from students will be collected through the pre-test. The pre-test represents the structure of the intended course, which is organized into several units. After the termination of the exam, the system provides material according to two cases. If the results of the examination exceed the grade set up by the teacher, the navigation link of the intended unit will disappear. Consequently, the material in the intended unit will not be presented. This means that the learner has good knowledge in the unit and does not need to learn the material. However, if the result is a lower score than the passing grade, it means that the learner does not understand the unit. It causes the navigation link of a particular unit to show up. Accordingly, the user could utilize the navigation unit link in order to obtain the related material. To support such cases, the adaptation engine uses the link hiding method. The navigation link for a particular unit is either hidden or shown depending on whether the user is passed the score limit. Below is the formula of the link hiding strategy for accommodating the knowledge level attribute.

$$\begin{gathered}\boldsymbol{if}\ unit_n score\ \geq score\_limit,\\ \boldsymbol{then}\ unit_n link\ is\ hidden,\\ \boldsymbol{else}\ unit_n link\ is\ shown.\end{gathered}$$

3.2.2.5. Design of User Interface

The design of user interface is the process of making interfaces of the software application based on the appearance. This phase aims to provide a general overview of the layout of components installed in the application. There are two types of components. While the first one is related to navigational elements such as link, button, slider, the second one concerns the informational components such as information text, information picture, and modal windows. The user interface design in this study is composed of designing 1) base layout, 2) knowledge level navigation layout, 3) sequential-global learning component layout, 4) visual-verbal learning component layout, and 5) active-reflective and sensing-intuitive learning component layout.

A. Base Layout

After establishing the set of rules to present and navigate the components, the work of layout design is conducted to provide full insight into the presentation of the layout framework.

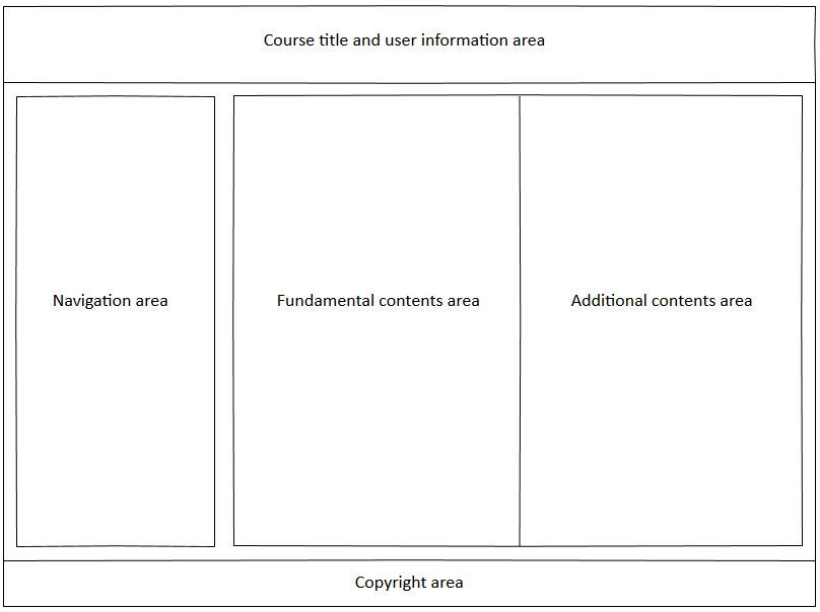


Figure 12. The layout framework of the learning environment

Figure 12 shows the base layout of the system, which consists of the following areas:

- The course title and user information area. This area is used to present the information regarding the adaptive system, subject title, and personal and academic data of the user.

- The navigation area. This area contains the links representing the units and sub-units of the course. The links in this area can be used to obtain the outline of the course as well as the learning style preference and pre- and post-test results. The links presented are dynamically changed based on the learner's initial knowledge. This area also has an adaptive capability to fit the sequential-global dimension of learning style.
- The fundamental content area. This area is allocated to the center of the screen for presenting learning materials. Since not all the learning materials can be described in one media format only, this area presents the learning materials in all media formats to improve student understanding. This area is a static area that has no capability to adapt to student's preferences.
- The additional content area. This area is located on the right side of the screen regardless of the student's style of learning and presents additional information in particular media formats. This area is a dynamic area that capable to change its content fit to student's preferences. For the visual learner, this area will provide the learning material in more visual media formats rather than in verbal media formats. In contrast, for verbal learners, this area will show more verbal media types rather than visual media types. The top of this area also provides buttons representing the active-reflective and sensing-intuitive dimension of the Felder-Silverman learning styles. Using the link hiding method, the buttons will be shown or hidden depending on the student's style of learning. When one of the buttons is clicked, an additional window will appear and provide extra information by giving particular learning activities.
- The copyright area. It is positioned at the bottom and provides brief information about the copyright of the system and how to contact the administrator.

B. Knowledge Level Navigation Layout

To determine the initial knowledge of the students, the students must take a pre-test prepared by the system. The questions on the pre-test represent all units in the course. Based on the result of the pre-test, the system decides the learning material, which will be shown in the learning environment.

The algorithm processes are based on two cases. First, if the result of the pre-test on a particular unit equals or exceeds the minimum grade set up by the teacher, it means that

the student is competent enough to complete the unit so that the link will be hidden. Second, if the result is lower than the minimum grade, it means that the student is not competent to complete the unit. They need to learn it so that the link will be shown, and the student can access the learning materials. In these cases, the link hiding method is used to control the appearance of the unit link. Figure 13 and Figure 14 show two different cases of knowledge navigation. Figure 13 shows the case where the results of the pre-tests in all units do not pass the minimum grade, whereas Figure 14 illustrates the case where one of the links is hidden because the student's pre-test in a particular unit has a good score.

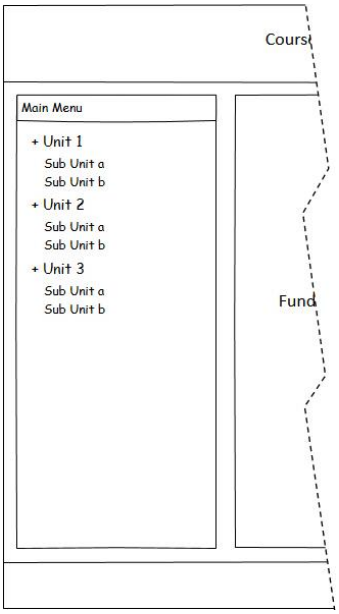


Figure 13. Links for all units (Units 1, 2, and 3) are shown

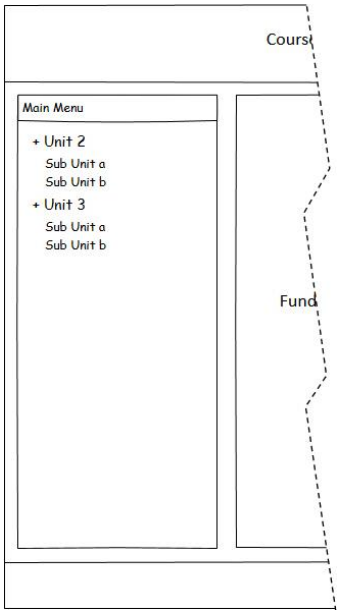


Figure 14. Links for units 2 and 3 appear, but unit 1 is hidden

C. Sequential-Global Learning Component Layout

A sequential type of learner prefers to absorb information in linear steps with one point on each page. To deal with this style of learning, "prev" and "next" buttons are installed to navigate through the learning material. The "next" button is used to jump to the next material, while the "prev" button returns to the previous material. Moreover, the main menu shows only the links for the units instead of displaying the sub-units in detail. Figure 15 depicts the layout design for the sequential learning style.

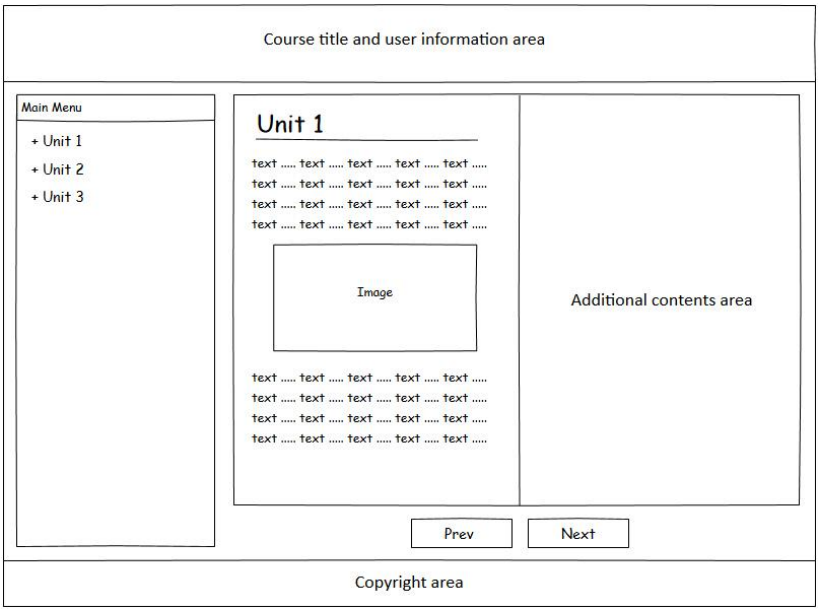


Figure 15. Sequential learning style layout

The global learner tends to think holistically, obtaining an overview of the course before jumping into the materials in detail. Figure 16 shows the layout design for the global learner type. The system provides links related to all units and sub-units to give a brief overview of the course. There is also a short explanation for each unit to give a comprehensive view of all the provided units.

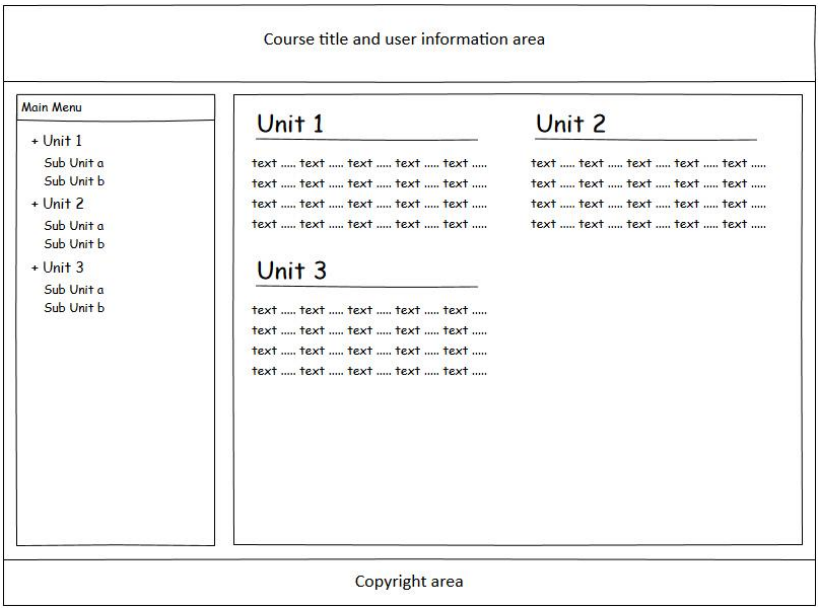


Figure 16. Global learning style layout

D. Visual-Verbal Learning Component Layout

Figure 17 and Figure 18 depict the different layout designs for visual and verbal learning styles. For the visual learner, the learning material is provided mostly using visual media such as images, video, and animation, while for the verbal learner, the learning material is provided by text, audio, and video.

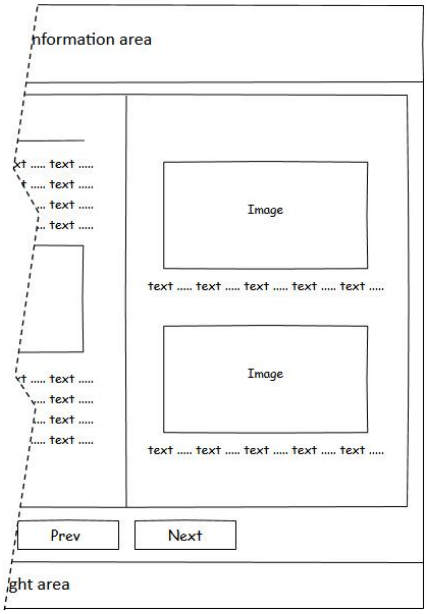


Figure 17. Visual learning style layout

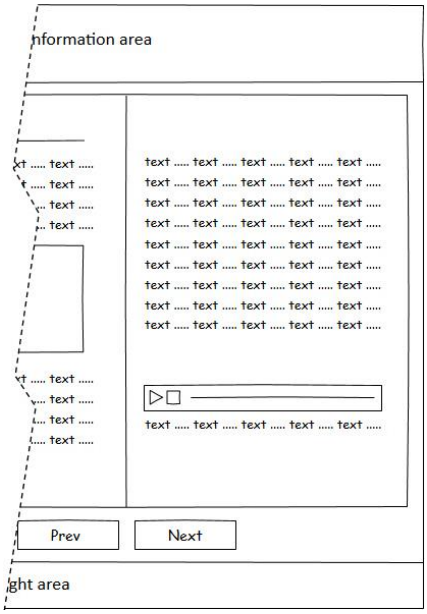


Figure 18. Verbal learning style layout

E. Active-Reflective and Sensing-Intuitive Learning Component Layout

To accommodate the active-reflective and sensing-intuitive dimensions of the Felder-Silverman learning styles, additional buttons are located at the top of the additional content area. Here, the buttons are correlated with the learning activities provided in the set of rules listed in Table 6.

For the active and sensing learner, for example, buttons for simulation, example, and synthesis will be displayed (see Figure 19). The user can access content by clicking the button, which will open a new window that provides the learning material through a particular learning activity.

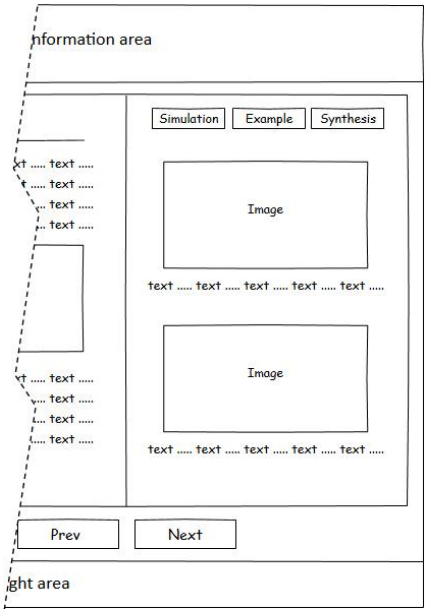


Figure 19. Active-Reflective and Sensing-Intuitive learning style layout

3.2.3. Third Phase: Development

The development phase is the process of producing the instructional system based on the data collected from two previous phases: the analysis and design phase. In the software engineering context, the development phase is the process for coding the software and to create all of the course materials. During this phase, instructional developers also test and validate each unit and module of instruction (Allen, 2006).

In this development phase, Jogiyanto (2005) suggested the developers for checking three common errors in computer programming, such as syntax error, run-time error, and logical error. The syntax error is an error in the syntax of coding, which mostly happened due to the typographical error made by a programmer. This error is the lowest level of error, and can be easily detected by the compiler and subsequently solved by the programmer. The run-time error occurs when the program is running and often forces the program to stop executing. The run-time error is at one level above the syntax error and sometimes need a longer time to address. Lastly, the logical error appears when the program is correctly executed but produces unintended or undesired output. As summarized by Panko (1998), based on the study from Allwood (1984), this kind of error is the most difficult error to be recognized and figured out immediately.

As mentioned previously in the analysis, in this study, the development of the adaptive e-learning system should consider the capability of the software to be smoothly accessed by many users simultaneously. The best choice to address that requirement is to use web-

based applications. Based on the analysis phase, Laravel is one of the most recommended web-based frameworks with many technical advantages.

The software development starts with coding or programming based on the architecture model, the user interface layout, the rules of adaptation, and the system flowchart. There will be 16 possibilities of the main user interface as a consequence of four dimensions of the learning style method used in this study. Thus, herein, we will only explain two different examples of learning style scenarios to provide a good understanding of how the system could work.

3.2.3.1. Scenario 1

This example will show the appearance of the Graphical User Interface (GUI) of an adaptive e-learning system based on the following student's preferences:

- The learning style of the student after taking the questionnaire is active-sensing-visual-sequential.
- The result of the pre-test indicates that the student score of each unit is lower than the standard grade set up by the teacher; in other words, the student is not competent enough to complete all units in the course.

The interface of the system based on the scenario above is shown in Figure 20.

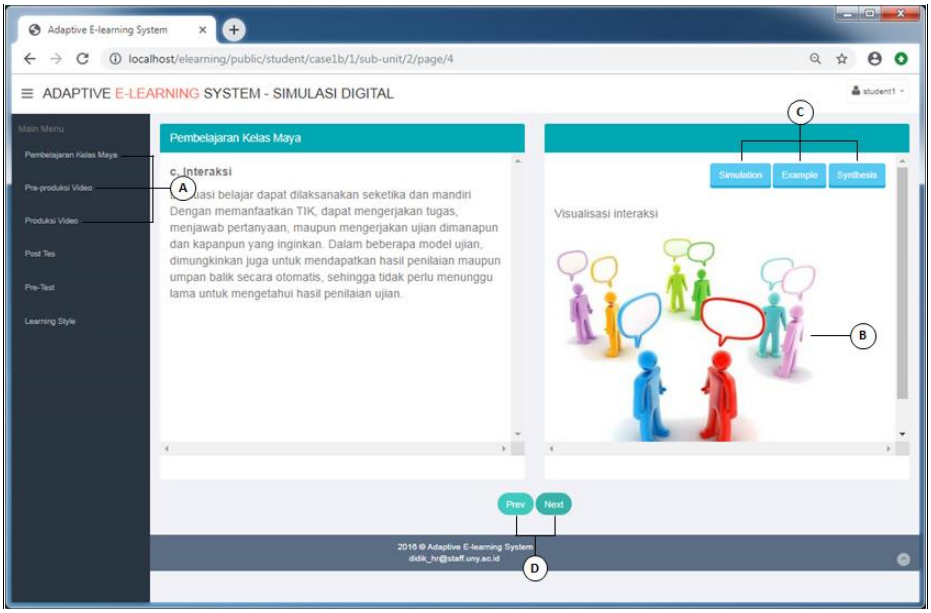


Figure 20. The user interface for scenario 1

The explanation regarding the figure above is as follows:

A. Since the score of the pre-test is lower than the standard grade of each unit, all the unit links appear (Unit 1: Pembelajaran Kelas Maya, Unit 2: Pra-produksi Video, and Unit 3: Produksi Video). For the sequential type, the menu shows only the unit links.
B. For the visual type, it shows visual media such as pictures.
C. For the active and sensing types, the Simulation, Example, and Synthesis buttons will be shown.
D. The “Prev” and “Next” buttons are shown for the sequential learner type.

3.2.3.2. Scenario 2

This part will show the appearance of the Graphical User Interface (GUI) of an adaptive e-learning system based on the following student’s preferences:

- The learning style is reflective-intuitive-verbal-global.
- The result of the pre-test indicates that the student score in Unit 2 exceeds the standard grade, but the results for Units 1 and 3 are lower than the standard grade. This indicates that the student has achieved competency for Unit 2 and does not need to learn Unit 2 (Pra-produksi Video) content. However, he/she should take the lesson for Unit 1 (Pembelajaran Kelas Maya) and Unit 3 (Produksi Video).

Figure 21 and Figure 22 show the interface of the adaptive e-learning system as described for scenario 2.

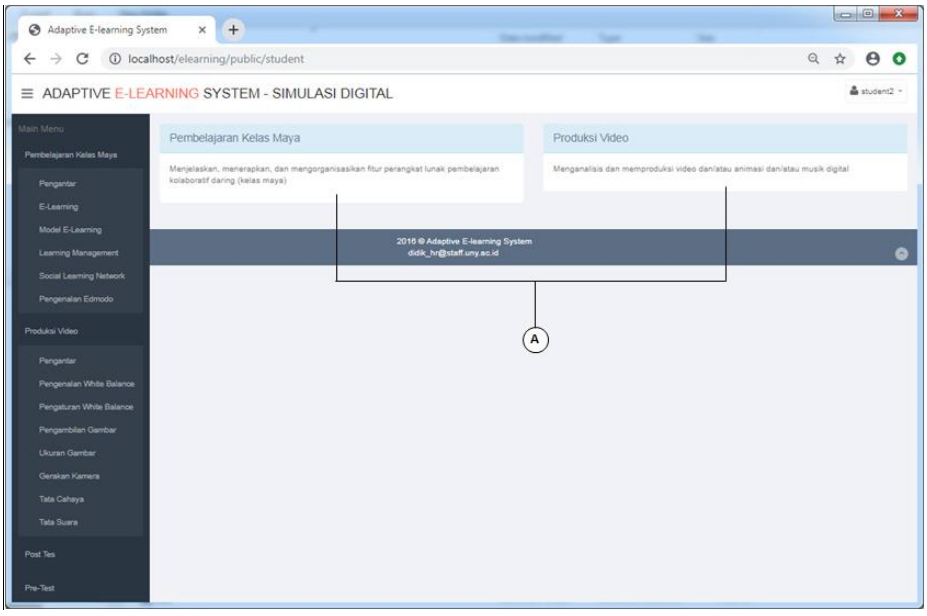


Figure 21. The first page of scenario 2

The explanation regarding the figure above is as follows:

A. For the global type, all units and a brief explanation of each unit are displayed. Two units (Unit 1: Pembelajaran Kelas Maya and Unit 3: Produksi Video) are displayed. Because the student is already competent in Unit 2 as indicated by the pre-test score, this Unit (Pra-produksi Video) is not displayed.

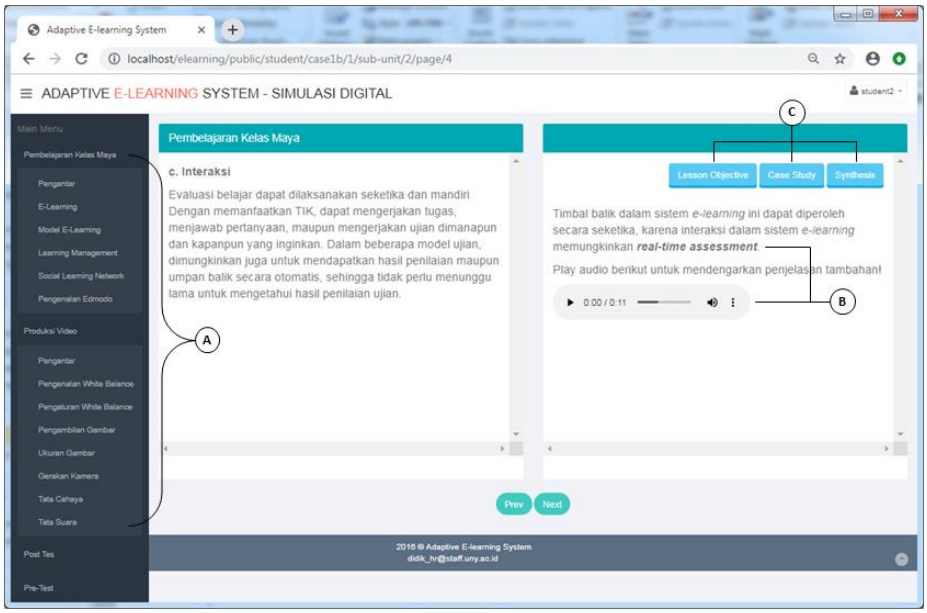


Figure 22. The user interface of scenario 2

The explanation regarding the figure above is as follows:

A. For the global type, all unit and sub-unit links in the navigation area are displayed.
B. For the verbal type, the information is provided in text and audio formats.
C. For the reflective and intuitive type, the Lesson Objective, Case Study, and Synthesis buttons are shown.

3.2.4. Fourth Phase: Implementation

This phase is the process of actual delivery of the instruction to the students in a small group setting. The small-scale studies with a few participants performed in preparation for the full-scale research setting are known as a pilot study (Ary, Jacobs, Irvine, & Walker, 2018). In social science research, the term pilot study used in two different ways (Van Teijlingen & Hundley, 2001). It can refer to so-called feasibility studies which are in a small-scale setting or trial test, conducted in preparation for the main study (Polit & Hungler, 1994). However, a pilot study can also be the preliminary testing of a particular research instrument in order to get the bugs out (Baker, 1988; Bell, 2005:147; Creswell, 2002:390). In

the context of software engineering, this pilot study can be used to identify software design issues (Izurieta & Bieman, 2007).

There is no specific recommendation regarding the number of participants required for the pilot study. It depends on many factors, such as time, cost, and the availability of people (Nieswiadomy & Bailey, 2008). Hertzog (2008) considered the size and variability of the population while dealing with the pilot sample. Nevertheless, previous studies recommended a sample size ranging from 20 to 40 to cover the population with a size between 80 and 250 (Kieser & Wassmer, 1996) whereas others have suggested that 10% of the population samples were required for the full-scale study size (Lackey & Wingate, 1997). Moreover, others have also suggested that as low as 10 participants are sufficient to conduct the study (Hertzog, 2008; Nieswiadomy & Bailey, 2008).

In this study, 21 students of the Department of Computer Network Technique of SMK 2 Pengasih participated in this pilot sample. Accordingly, the number of participants in this study meets with the minimum recommendation suggested by previous studies, as discussed above. The pilot study lasted roughly three hours in the computer laboratory in the first semester of the academic year 2017/2018. The session started by giving a brief introduction about the objectives of the study, the learning software, and how to use the instruction system. In the following session, the participants were asked to access the learning system with the login information, which was distributed previously. Then, learners took part and used the instruction system in the training environment freely. In the last session of the learning process, the paper-based usability questionnaire was distributed to the students, and the students were asked to answer the question about their experiences when they used the system. They were also expected to give open comments and suggestions concerning the design issues in the context of both instructional and technical. The student's responses were used to correct the issues found. The detailed procedure and results can be found in the next sub-chapter Students Evaluation.

3.2.5. Fifth Phase: Evaluation

The final stage of ISD is evaluation and assessment. This phase evaluates the effectiveness and efficiency of the instruction system and also the design of the Graphical User Interface (GUI). The evaluation phase should accommodate the entire instructional design process.

Lohr (1998) pinpoints that the evaluation phase addressed both formative and summative assessment processes. The formative evaluation is conducted throughout the entire phase of the ADDIE method. The purpose of this type of evaluation is to improve the instruction system before the final version is implemented. Moreover, the summative evaluation is conducted after the final version of the instruction was prepared. The purpose of this evaluation is to assess the overall effectiveness and efficiency of the instruction system.

The following evaluation has been conducted in order to ensure the design and development of the instructional system meet the standard requirements. Three evaluations have been completed, namely, functional testing, expert-based evaluation, and user-based evaluation. Functional testing is strongly related to software testing in order to eliminate instructional software bugs. Expert-based evaluation is conducted based on the judgment of the group of scientific experts who is competent in a specific subject while user-based evaluation aims to get the student's perspective while they are experiencing the instructional media.

3.2.5.1. Functional Testing

To assess the performance of the adaptive user interface approach, software testing was conducted. Software testing is a critical element in software development to eliminate software bugs and to ensure that the software can run as planned (Pressman, 2005). Williams (2006) mentioned that one of the basic tests for software testing is black-box testing. Luo (2001) referred to black-box testing as functional testing. This test focuses only on the outputs generated by the system with specific inputs and ignores the internal mechanism of a system or component (IEEE, 1990). The functional test was administered by trying some combinations of learning styles and knowledge levels as inputs. Since four dimensions of the Felder-Silverman learning styles are used in this approach, 16 possible learning styles should be prepared as the scenario tests.

Sixteen combinations of a knowledge test and learning style preference results were used as input tests. For each input test, the behavior of the system was observed to determine whether it responds as designed or not. The results of the visual observation of the system's user interface are reported in Table 9. The results of the functional test showed that the proposed adaptive e-learning system could react as expected. The system could change its user interface automatically based on different inputs of learning style and initial student knowledge.

Table 9. Functional test results

Test Case	Combinational Input									Functional Test Result
	Pre-Test					Learning Style				
	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Dimension 1	Dimension 2	Dimension 3	Dimension 4	
1	Fail	Fail	Fail	Fail	Fail	Active	Sensing	Visual	Sequential	The system responds as designed
2	Pass	Fail	Fail	Fail	Fail	Active	Sensing	Visual	Global	The system responds as designed
3	Fail	Pass	Fail	Fail	Fail	Active	Sensing	Verbal	Sequential	The system responds as designed
4	Fail	Fail	Pass	Fail	Fail	Active	Sensing	Verbal	Global	The system responds as designed
5	Fail	Fail	Fail	Pass	Fail	Active	Intuitive	Visual	Sequential	The system responds as designed
6	Fail	Fail	Fail	Fail	Pass	Active	Intuitive	Visual	Global	The system responds as designed
7	Pass	Fail	Fail	Fail	Fail	Active	Intuitive	Verbal	Sequential	The system responds as designed
8	Fail	Pass	Fail	Fail	Fail	Active	Intuitive	Verbal	Global	The system responds as designed
9	Fail	Fail	Pass	Fail	Fail	Reflective	Sensing	Visual	Sequential	The system responds as designed
10	Fail	Fail	Fail	Pass	Fail	Reflective	Sensing	Visual	Global	The system responds as designed
11	Fail	Fail	Fail	Fail	Pass	Reflective	Sensing	Verbal	Sequential	The system responds as designed
12	Pass	Fail	Fail	Fail	Fail	Reflective	Sensing	Verbal	Global	The system responds as designed
13	Fail	Pass	Fail	Fail	Fail	Reflective	Intuitive	Visual	Sequential	The system responds as designed
14	Fail	Fail	Pass	Fail	Fail	Reflective	Intuitive	Visual	Global	The system responds as designed
15	Fail	Fail	Fail	Pass	Fail	Reflective	Intuitive	Verbal	Sequential	The system responds as designed
16	Fail	Fail	Fail	Fail	Pass	Reflective	Intuitive	Verbal	Global	The system responds as designed

3.2.5.2. Evaluation by Experts

The evaluation by experts is conducted in two different perspectives, the first evaluation is based on the learning content aspects, and the second is concerning the media aspects. The assessment of learning content will evaluate the suitability of the structure and the content of a particular topic to the curriculum. This evaluation will be done by the experts of an intended subject. Meanwhile, the media expert will evaluate the appearance and the use of multimedia (color, text, picture, sound, etc.) in the instructional software. The results of the

evaluation, as well as the open comments and suggestions from the experts, can be used for further improvement and the next refinement of the software.

A. Evaluation by Experts concerning the Learning Content and its Structure

In this study, the evaluation of the learning content started by constructing the instruments of assessment according to its purpose (Crocker & Algina, 1986). The next stage was identifying the criteria of assessment by reviewing some related literature. After considering several aspects, the criteria were adopted from the established learning content assessment made by the Ministry of National Education of Indonesia (Direktorat Pembinaan SMA Kemdiknas, 2010).

Table 10. The outline of the content aspect questionnaire

No	Aspects	Indicators	Items Number	References
1.	Material Substance	Correctness	1, 2, 3	Direktorat Pembinaan SMA Kemdiknas (2010)
		Scope	4, 5	
		Novelty	6, 7	
		Readability	8, 9	
2.	Learning Design	Title	10	Direktorat Pembinaan SMA Kemdiknas (2010)
		Competence Standard and Basic Competence	11, 12	
		Learning Objective	13	
		Learning Material	11, 12	
		Example	14, 15	
		Exercise	16, 17	
		Author	18	
		Reference	19	

Two aspects of assessment, namely: material substance and learning design, were considered. The material substance aspect has four indicators, with nine items of question. Meanwhile, the learning design aspect has eight indicators, with ten items of questions. All of the questions are in positive wording format and structured as a 4-point Likert scale. The detailed outline of the questionnaire can be seen in Table 10.

The first draft of this questionnaire was given to two scientific experts who had an academic background in evaluation and on the intended topic. This process aimed to check

the content validity of the instrument. Many definitions of content validity have been published previously (American Educational Research Association, 1999; Anastasi & Urbina, 1997; Messick, 1987; Nunnally & Bernstein, 1967; Suen & Ary, 2014; Walsh & Betz, 1995). Haynes et al. (1995) encapsulated the definition of the content validity from those researchers in a so-called logical or rational validity, or the accuracy of the test items to represent the construct to which the test will be used to measure. This validity can be examined by a rational analysis of competent panelists or experts. After considering their comments and suggestions, the questionnaire was revised and then made as a final version. (see Appendix A).

The following step was to hand out the questionnaire to the group of subject experts. In total, three subject related teachers were involved in this evaluation. The questionnaire was distributed in a paper-based format. In the beginning, a brief explanation about the e-learning software and the operating procedures were explained to the teachers. Then, they were given a chance to access and explore the e-learning software individually. The learning content was evaluated by the experts by giving one mark out of four-point Likert scale in each item of the questionnaire. After the completion, they were also asked to give constructive comments or suggestions concerning the learning content and its structure.

Table 11. The results of the content aspect evaluation

Experts	Material Substance		Learning Design		Average	
	Mean Score	0-100 Score	Mean Score	0-100 Score	Mean Score	0-100 Score
Expert 1	3.89	96.30	4.00	100.00	3.95	98.25
Expert 2	3.89	96.30	3.60	86.67	3.74	91.23
Expert 3	3.00	66.67	3.40	80.00	3.21	73.68
Average	3.59	86.42	3.67	88.89	3.63	87.72

The summary of the assessment results can be seen in Table 7. Nielse (1993) mentioned that the evaluation of results could be analyzed by comparing the mean value of each variable. Debevc & Bele (2008) suggested the use of the traditional school score in the range of 0-100 to describe the results. As indicated by the average 0-100 score from all the experts, the mean values exceeded the score limit of 50, which is the minimum score to be judged as acceptable. Additionally, the total average score of 87.72 also showed that 87.72% of the experts are satisfied with the learning content of the system.

B. Evaluation by Experts concerning the Learning Media used

This section explained the process of evaluating media used in the learning material of the e-learning system. The first stage is to take into account the purpose of evaluation when constructing the instruments (Crocker & Algina, 1986). Since the evaluation is related to the media, the development criteria of the instruments start with a literature review on the media evaluation. For this, some works authored by Direktorat Pembinaan SMA Kemdiknas (2010), Ivers & Barron (1998), Mishra & Sharma (2004), and Vaughan (2011) have been analyzed. As a result, two aspects of the assessment which are related to the visual interface and the software utilization were applied. The aspect of visual interface consists of five indicators with 16 questions. In contrast, the software utilization aspect is represented by three indicators with four questions. The positive wording format is used to develop all of the questions, and the 4-point Likert scale ranging from "strongly agree" to "strongly disagree" is used to measure the respondent's opinions.

Table 12. The outline of the media aspect questionnaire

No	Aspects	Indicators	Items Number	References
1.	Visual Interface	Navigation Support	1, 2, 3, 4	Direktorat Pembinaan SMA Kemdiknas (2010), Vaughan (2011), Ivers & Barron (1998)
		Typography	5, 6, 7	
		Media	8, 9, 10, 11, 12	
		Color	7, 13	
		Layout	14, 15, 16	
2.	Software Utilization	Interactive	17, 18	Direktorat Pembinaan SMA Kemdiknas (2010), Mishra & Sharma (2004)
		Software Support	19	
		Originality	20	

After the first draft instrument was formed, the content validity of the instrument was checked by two experts of the evaluation and topic-related. Based on their comments, some of the statements of the questionnaire were modified to improve clarity and readability. The final version of the questionnaire can be seen in Appendix B.

The next step was to choose a competent media-based expert to examine the e-learning system. The questionnaire of the media evaluation was distributed to two experts in a paper-and-pencil format. Prior to its circulation, the information about the e-learning software and the instructions to operate was explained briefly. The expert should choose

one out of four options of Likert scale to express their agreement on the system. The expert could also give some open comments for further improvement.

Table 13. The results of the media aspect evaluation

Experts	Visual Interface		Software Utilization		Average	
	Mean Score	0-100 Score	Mean Score	0-100 Score	Mean Score	0-100 Score
Expert 1	3.25	75.00	3.25	75.00	3.25	75.00
Expert 2	3.38	79.17	3.75	91.67	3.45	81.67
Average	3.31	77.08	3.50	83.33	3.35	78.33

Table 13 exhibits the results of expert assessment regarding the media aspect. According to Debevc & Bele (2008), the 0-100 score average of 78.33 is considered to be acceptable as it is above the threshold score of 50. It also can be concluded that 78.33% of the expert satisfied with the media aspect of the instructional system.

3.2.5.3. Students Evaluation

In this part, the evaluation was focused on the student's experience while interacting with the instructional program of the e-learning system. Since there is considerable interaction between the students (human) and computer, the evaluation was conducted based on the Human-Computer Interaction (HCI) theory that takes into account the usability of the system as an essential key factor (Parlangeli et al., 1999). The evaluation of the usability is carried out by gathering information on the user's perspective using many methods, e.g., thinking aloud, field observation, and questionnaires (Holzinger, 2005). It is also important to note that usability evaluation does not assess a system in a single dimension only, but also consider many other aspects. One questionnaire model that follows this approach has been introduced by Lund (2001). He proposed the USE Questionnaire that includes four attributes, like the usefulness, satisfaction, ease of use, and ease of learning as aspects of assessment.

In this study, the USE Questionnaire is used as a student-based evaluation in order to measure the usability of the e-learning system. Since the original USE Questionnaire was formed in the English language, the questions were translated into Indonesian so that the Indonesian respondents can understand them easily. A credible translator was involved in

the translation process, and the final version was compiled by considering certain aspects of the items' meaning.

Table 14. The outline of the user-based evaluation questionnaire

No	Aspects	Indicators	Items Number	References
1.	Usability	Usefulness	1, 2, 3, 4, 5*, 6, 7, 8	Lund (2001)
		Ease of Use	9, 10, 11, 12, 13, 14*, 15, 16, 17, 18, 19	
		Ease of Learning	20, 21, 22, 23	
		Satisfaction	24, 25, 26*, 27, 28, 29, 30	

Note:
*: negative wording question

This questionnaire has four aspects of assessment with a total of 30 questions. In order to minimize the response and acquiescent bias, three selected questions were constructed in a negative wording format. A 4-point Likert scale was chosen to accommodate the respondent's perception. The outline of the questionnaire is shown in Table 14.

As it is already explained in the implementation phase, 21 students were involved in this evaluation. In general, the students were asked to interact with the e-learning software for around three hours in order to thoroughly evaluate the user's experience. Next, they were asked to give feedback by filling out the provided USE Questionnaire. Due to an incomplete response, 2 data from Student 4 & 16 were eliminated from the analysis. The results of the student-based evaluation can be seen in Table 15.

Table 15. The result of the user-based evaluation

Respondents	Usefulness		Ease of Use		Ease of Learning		Satisfaction		Average	
	Mean Score	0-100 Score	Mean Score	0-100 Score	Mean Score	0-100 Score	Mean Score	0-100 Score	Mean Score	0-100 Score
Student 1	3.25	75.00	3.27	75.76	3.00	66.67	3.43	80.95	3.24	74.59
Student 2	3.38	79.17	3.45	81.82	3.75	91.67	3.43	80.95	3.50	83.40
Student 3	2.75	58.33	3.00	66.67	3.00	66.67	3.00	66.67	2.94	64.58
Student 5	3.38	79.17	2.82	60.61	2.50	50.00	2.43	47.62	2.78	59.35
Student 6	3.50	83.33	3.45	81.82	3.50	83.33	3.29	76.19	3.44	81.17
Student 7	3.63	87.50	3.45	81.82	3.00	66.67	3.00	66.67	3.27	75.66
Student 8	2.75	58.33	2.91	63.64	3.00	66.67	3.00	66.67	2.91	63.83
Student 9	3.13	70.83	2.91	63.64	2.75	58.33	3.00	66.67	2.95	64.87
Student 10	3.25	75.00	2.73	57.58	2.50	50.00	2.71	57.14	2.80	59.93

Student 11	3.00	66.67	2.91	63.64	3.25	75.00	3.14	71.43	3.08	69.18
Student 12	3.25	75.00	3.09	69.70	3.00	66.67	3.14	71.43	3.12	70.70
Student 13	3.50	83.33	3.27	75.76	3.25	75.00	3.57	85.71	3.40	79.95
Student 14	3.25	75.00	3.09	69.70	3.50	83.33	3.14	71.43	3.25	74.86
Student 15	2.75	58.33	3.36	78.79	3.75	91.67	3.29	76.19	3.29	76.24
Student 17	3.13	70.83	3.27	75.76	3.75	91.67	3.29	76.19	3.36	78.61
Student 18	2.75	58.33	3.00	66.67	3.00	66.67	3.00	66.67	2.94	64.58
Student 19	3.13	70.83	3.00	66.67	3.00	66.67	3.00	66.67	3.03	67.71
Student 20	3.38	79.17	3.45	81.82	3.75	91.67	3.00	66.67	3.39	79.83
Student 21	3.13	70.83	4.00	100.00	4.00	100.00	3.29	76.19	3.60	86.76
Average	3.17	72.37	3.18	72.73	3.22	74.12	3.11	70.43	3.17	72.41

In general, the results table demonstrated that the student reactions toward the e-learning system are considered positive. The average “0-100 score” for each variable exceeded the acceptable limit score of 50 set by Debevc & Bele (2008). The average score of 72.41 meant that 72.41% of students agree that the e-learning system was acceptable in terms of the usefulness, ease of use, ease of learning, and satisfaction.

3.3. Experimental Research Design

This chapter elucidates the appropriate method used in this study. It starts by analyzing the characteristics of the study and taking into account the primary objective to be clarified. It is noteworthy to keep in mind that one of the main aims of this study is to investigate whether the proposed adaptive e-learning system drives a better learning achievement for students. Another critical point to analyze is the satisfaction of the students who used the adaptive e-learning system for the learning process.

3.3.1. Research design

The research design refers to a systematic approach used by a researcher to integrate various components of research in order to address the research problem in an effective manner. The research design can either be classified into quantitative or qualitative research design. It is important to point out that the aim of this study is to examine whether the use of an adaptive e-learning system could have a better impact on the learning process compares with the traditional learning setting. Since this comparison study is closely related to gathering quantitative data and performing statistical and mathematical analysis, it could be classified as the quantitative research approach.

Quantitative research can be distinguished into the four essential methods (Black, 2002; Gall, Borg, & Gall, 1996), such as 1) descriptive research design; it refers to describing the situation, phenomena or case; 2) survey research design; it is the most fundamental method to gather the respondent opinion from various options of questionnaire types; it is sometimes referred to the correlational research design which establishes a relationship between two closely variables and how one impacts another; 3) experimental research design; it is also known as a true experimentation and often used in social sciences which include two or more groups to compare the experimental groups with others; 4) quasi-experimental research design; this type is almost similar to an experimental research design with fewer controlling all the key factors. In this study, amongst the four types of quantitative research approach, the experimental research design was selected due to the suitability to handle the research objectives. This study involved two groups that took the pre- and post-test before and after a distinct treatment, respectively. Accordingly, this experimental design is known as a pre-test - post-test control group design (Cohen, Manion, & Morrison, 2002; Leavy, 2017). The pre-test - post-test control group design is commonly used in educational research specifically to investigate the effects of educational learning media on the learning process.

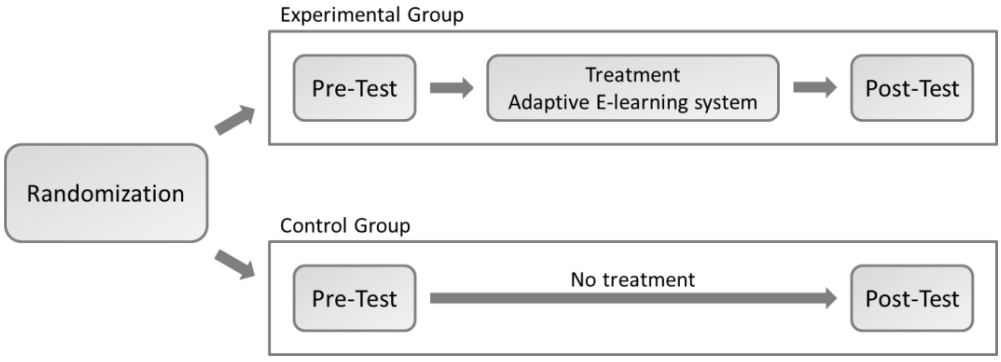


Figure 23. The experimental research design of the study

Figure 23 illustrates the experimental research design used in this study. This study contains one experimental group and one control group. Before the experiment, the random assignment was conducted to the study groups. Each group was measured through a pre-test before the intervention and by post-test afterward. The experimental group received a proposed treatment, and the control group received regular treatment. The proposed treatment in this study was the use of an adaptive e-learning system in the learning activity, while the regular treatment was following the traditional classroom teaching setting.

There are two main variables in the experimental research design, i.e., the independent variable and the dependent variable. The main issue regarding both variables is how the independent variable causes changes in the dependent variable scientifically. As seen in Table 16, the independent variable controlled in this experiment is the adaptive e-learning system, while the dependent variable is the knowledge level.

Table 16. Variables of the experimental study

Independent variable	Dependent variable
Adaptive E-learning System	Knowledge Level

In this study, the user's perspective when they use the adaptive e-learning system also explores through usability evaluation. The USE Questionnaire proposed by Lund (2001) is used as the usability questionnaire. This questionnaire composes of four variables, namely usefulness, ease of use, ease of learning, and satisfaction. Each variable is measured based on its acceptance level. The variable's usefulness, ease of use, and ease of learning are included in the independent variables, while satisfaction belongs to the dependent variable (see Table 17).

Table 17. Variables of the usability evaluation

Independent variable	Dependent variable
Usefulness	Satisfaction
Ease of Use	
Ease of Learning	

Besides, the relational amongst the variables on the USE Questionnaire needs to be determined. The purpose of this approach is particularly to identify the relationship between the independent and the dependent variable either partially or simultaneously. The proper research design to overcome this problem is the correlational research design.

3.3.2. Research sample

The study was conducted in one public vocational high school in Kulon Progo, DI Yogyakarta Province, Indonesia, SMK N (Sekolah Menengah Kejuruan Negeri, or Public Vocational High School) 2 Pengasih. The students involved in this study were 1st-grade students at the Department of Computer Network Technique in the academic year of 2017/2018. In this department, the students were divided into three groups, including TKJ1 (20 students), TKJ2

(21 students), and TKJ3 (21 students). In order to reduce the threat at the study, Black (2002) suggested using the random techniques for selecting the sample. The random sampling refers to a strategy to choose an individual from a broader set of a population in which each individual has an equal probability of being selected (Kothari, 2009). Currently, several different sampling techniques are available. Notably, for probability random sampling, the methods can further be divided into 1) the simple random sampling, 2) the systematic sampling, 3) the stratified sampling, 4) the clustered sampling, and 5) stage sampling (Blum & Foos, 1986; Cohen et al., 2002; Kerlinger & Lee, 1999; O'Leary, 2017).

As described above, the students have been grouped into three groups, and it is important to note that each group has a meeting schedule specified by the school already. Consequently, the meeting schedule of each group could not change freely. It arises because of some factors, i.e., the availability of classroom, laboratory or workshop, the availability of teachers, and learning hours. It is also impossible to pick one student up randomly and put his/her on a random group as well. Therefore, the suitable random sampling technique used in this study was based on the cluster random sampling instead of an individual selection. The meaning of cluster used in this random technique is the random selection conducted based on the group. To deal with the random procedure, each group was labeled with the number. Afterward, the numbers were selected randomly and classified either as the control group or the experimental group. As a result, the control group was the TKJ2 group, which contained 21 students, and the experimental group was the TKJ3 group, which consisted of 21 students as well.

Another parameter to be considered when dealing with the sample selection is the homogeneity of the datasets from several sample groups. In SMK N 2 Pengasih, the candidates who want to enroll in one of the departments should follow some criteria. One of the criteria is based on the national exam score from the previous school. As such, it could be assumed that both study groups were homogenous in terms of prior knowledge. The students involved in this study ranged from 16 to 17 years old. Moreover, SMK N 2 Pengasih, as one of the public schools, should accept the students in any level of economic and social. Therefore, both study groups were assumed to be equal in terms of the level of prior knowledge, age, economic, and social. This assumption confirms that the homogeneity concern is fulfilled as a prerequisite to conduct experimental research.

The further process was ensuring the homogeneity based on the statistical analysis. The homogeneity of variances test has also been completed using the statistical procedure in terms of the pre-test score. From Table 18, the result showed that Sig. value (0.108) exceeding the significant level (0.05), indicating no significant difference between the experimental group and the control group before treatment. Therefore, both groups were homogenous for their prior knowledge.

Table 18. Test of homogeneity of variances

Levene Statistics	df1	df2	Sig.
2.696	1	40	0.108

3.3.3. Research instruments

In this study, two instruments were prepared in order to obtain empirical data to address the research objectives. The first instrument was the knowledge test instrument, which was used as a pre- and post-test. This instrument was applied to both the experimental and control group students. A pre-test was utilized to measure the initial knowledge level of each student, while a post-test was used to measure the student's knowledge level after receiving a specified treatment. The second instrument was used to evaluate the usability of the e-learning system. This instrument was given to the students who experience the learning process through the adaptive e-learning system designed and developed by the researcher. This section will describe the construction and development of those instruments.

3.3.3.1. Knowledge Test

In the learning and teaching process, one crucial part of getting adequately managed is the knowledge test. The knowledge test aims to measure the level of information acquired by the students who participated in the education process after a specific treatment. It could help in evaluating the effectiveness of the teaching instructions and instructional media. In this study, the knowledge test was constructed based on the objectives of teaching and learning. To address that, the process was started by reviewing the established syllabi developed previously by the group of teachers. As a result, the intended subject was arranged to accommodate the first three-level of Bloom's taxonomy, i.e., knowledge, comprehension, and application. This result is in line with the suggestion from Esiobu &

Soyibo (1995) to measure the student's understanding of science concepts beyond the comprehension level on Bloom's taxonomy. Besides, it is also aligned with the study conducted by Thompson & Soyibo (2002) to test the student's understanding by considering the three lowest levels of Bloom: knowledge, comprehension, and application level.

The following step was to determine what kinds of content to be tested. The subject used in this experimental study was Digital Simulation, which covered the content of the following units: 1) online class learning, 2) video pre-production stage, and 3) video production stage. Accordingly, the test items for the knowledge test were prepared. The process was conducted by reviewing the course outline, the student's handbook, and the already available test items. After studying them thoroughly, the first draft of the knowledge test was developed and comprised of 30 items. The items were framed in the form of multiple-choice questions with five possible choices in which only one option was correct. In this case, students were expected to choose one right answer amongst the five possible responses. The number of items for each level of Bloom's cognitive domain as follows: knowledge level (15 items), comprehension level (11 items), and application level (4 items). The outline of the knowledge test in detail, including its relative weights in each level, can be seen in Table 19.

Table 19. The number of items and its relative weights of each cognitive level

Course Unit	Cognitive Level			Total
	Knowledge	Comprehension	Application	
Online Class Learning	4 (13.33%)	5 (16.67%)	1 (3.33%)	10 (33.33%)
Video Pre-production Stage	5 (16.67%)	4 (13.33%)	1 (3.33%)	10 (33.33%)
Video Production Stage	6 (20%)	2 (6.67%)	2 (6.67%)	10 (33.33%)
Total	15 (50%)	11 (36.67%)	4 (13.33)	30 (100%)

The first draft of the instrument was then given to the group of teachers with expertise on an intended subject. This process aimed at checking the readability, the clarity, the understandability, and suitability to the syllabi. The comments and suggestions from the experts were considered for modifying and finalizing the test's instrument.

The following step was administered the finalized draft of the knowledge test in the pilot study. 21 students of the Department of Computer Network Technique of SMK 2 Pengasih participated in the pilot study. The knowledge test was prepared as a pre-test that should

be taken by participants at the beginning step of using the e-learning system. This knowledge test was formed as a web-based platform that is available as one module in the e-learning system.

The collected data were then analyzed in order to determine the internal reliability. Cronbach's Alpha was chosen to examine the data reliability level with a value of 0.7 as the cutoff point. As seen in Table 20, the Cronbach's Alphas of the knowledge test for each Bloom's level are in the acceptable criteria.

Table 20. Reliability score for each level of knowledge test

Cognitive Level	N of items	Cronbach's Alpha
Knowledge	15	0.705
Comprehension	11	0.707
Application	4	0.743

3.3.3.2. Usability Evaluation

In the theory of Human-Computer Interaction (HCI), usability is an essential aspect that refers to the quality of user interface (Parlangeli et al., 1999). The main concern in the usability evaluation is gathering information from a user perspective about a product or system with many methods, e.g., thinking aloud, field observation, and questionnaires (Holzinger, 2005). In the context of e-learning, usability testing more focuses on the learning experience of users in an e-learning system.

Many standardized and well-known questionnaires could be used for evaluating the usability of the products based on the user perspective. However, the one that is widely used in education fields and offers many advantages in terms of economic, reasonable number of questions, and item understandable is the USE Questionnaire. Initially, the USE Questionnaire composed of three dimensions: Usefulness, Satisfaction, and Ease of Use. However, for the specific situation, the items on Ease of Use could be separated further into Ease of Use and Ease of Learning where both are highly correlated.

Initially, the questionnaire was developed in the English language. Since the respondents involved in this study were Indonesian students, it was then translated into the Indonesian version by a credible translator from a language unit of a reputable university. The final

version was compiled by considering readability and meaningfulness aspects in order to accurately represent the original document.

The questionnaires consist of 30 questions to represent four aspects of usability measurement. All of the questions were constructed in a positive wording format initially, but then three of them were reversed into negative wording. This strategy was used in order to minimize response and acquiescent bias. The combination of positive and negative phrasing may force the respondents to read each question carefully and provide meaningful responses. The questionnaires were constructed with a 4-point Likert rating scale starting from point 1 to indicate a strong disagreement to point 4 to represent a strong agreement. The outline of the questionnaire can be seen in Table 14 of the previous chapter.

The reliability of the questionnaire was examined by conducting a pilot study. As it is already explained in the implementation phase of the previous chapter, the pilot study was done in the first semester of the academic year 2017/2018. 21 students were involved in this small-scale test. The students were provided an opportunity to experience the learning system for about three hours in the computer laboratory. After completing the experiment, the students were asked to express their opinion by giving a rating with a Likert scale for the provided questionnaire. Two incomplete responses were eliminated for further analysis; thus, the total used data was 19. The Cronbach's Alpha was calculated using SPSS to estimate the reliability coefficient.

Table 21. The reliability coefficient of each aspect of the USE questionnaire

Aspects of Usability	N of items	Cronbach's Alpha
Usefulness	8	0.705
Ease of Use	11	0.822
Ease of Learning	4	0.782
Satisfaction	7	0.711

It is generally agreed that the instrument could be considered reliable when the threshold value of Cronbach's alpha is at least 0.7 (Landauer, 1997; Nunnally, 1978; Robinson, Shaver, & Wrightsman, 1991). As shown in Table 21, the Cronbach's Alpha score for four variables (usefulness, ease of use, ease of learning, and satisfaction) was higher than the reliability threshold, indicating the reliability of the questionnaire.

3.3.4. Research procedures

The research procedure described the steps to be taken for performing the experimental research. It includes the instructional treatment for the experimental group and the control group, the procedure to collect the data, and the process of data analysis.

3.3.4.1. Instructional Treatment

The experiment in this study was conducted in one of the public vocational high schools in Yogyakarta, Indonesia. The study lasted for a total of 20 lesson hours in four meetings in the second semester of the academic year 2017/2018. In that academic year, the learning process held in the block scheduling system. Block scheduling is an academic scheduling system where the students have fewer classes per day with a more extended meeting period than usual (Imbimbo & Gilkes, 2009). This system tries to replace the traditional schedule that typically has one meeting per week and a shorter meeting period. This scheduling system was proposed to encourage the students for learning (National Education Commission Learning, 1994)

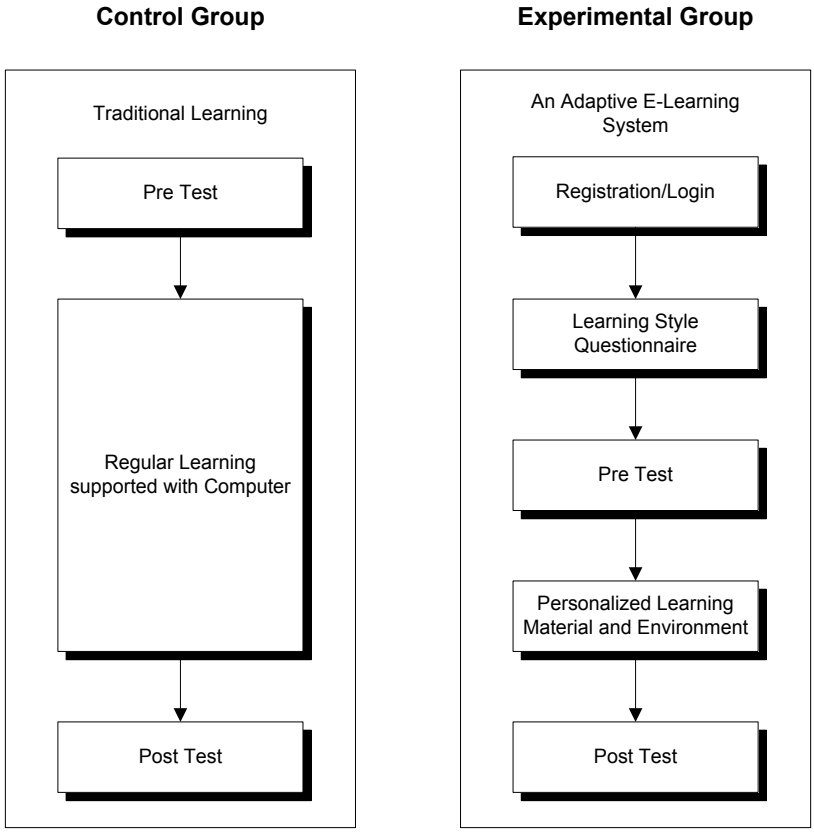


Figure 24. The experiment procedure

The subject delivered in this study is a Digital Simulation for the 1st-grade students of the Computer Network Technique Department. This course focused on the utilization of information and communication technology in the learning process through the development of web-based teaching materials. In this experiment, it only focused on three units, 1) online class learning, 2) video pre-production stage, and 3) video production stage.

Two groups of students were involved in this study, an experimental group and a control group. The experimental group utilized the adaptive e-learning system with minimum interaction with the teacher. Meanwhile, the control group participated in a traditional learning process with the teacher as the primary instructor. Both experimental and control groups were taught by the same teacher.

The students in the traditional classroom participated in the learning process in the classroom equipped with a computer. The use of computers in the lesson was inevitable because the learning content was related to computer-based activities. As can be seen in Figure 24, the students in the control group firstly took the pre-test. The pre-test was distributed in a paper-and-pencil format. The pre-test was used to examine the initial knowledge level of each student. The learning content was then taught by the teacher using different techniques such as lecture presentation, question and answer, demonstration, and group discussion. The instructional material in this group included the textbook and teacher notes. The learning process continued for specific learning hours as planned. In the end, the post-test was distributed to the students. This post-test was used to measure the knowledge achievement of each student after following the traditional learning activities.

The students in the experimental group experienced a learning process through an adaptive e-learning system. They used the computer laboratory supported by a high-speed network cable. The first session started by giving a brief introduction about the adaptive e-learning system and the accessibility via web-browser. Each student was also informed of the login information (username and password) and the registration process (see Figure 25).

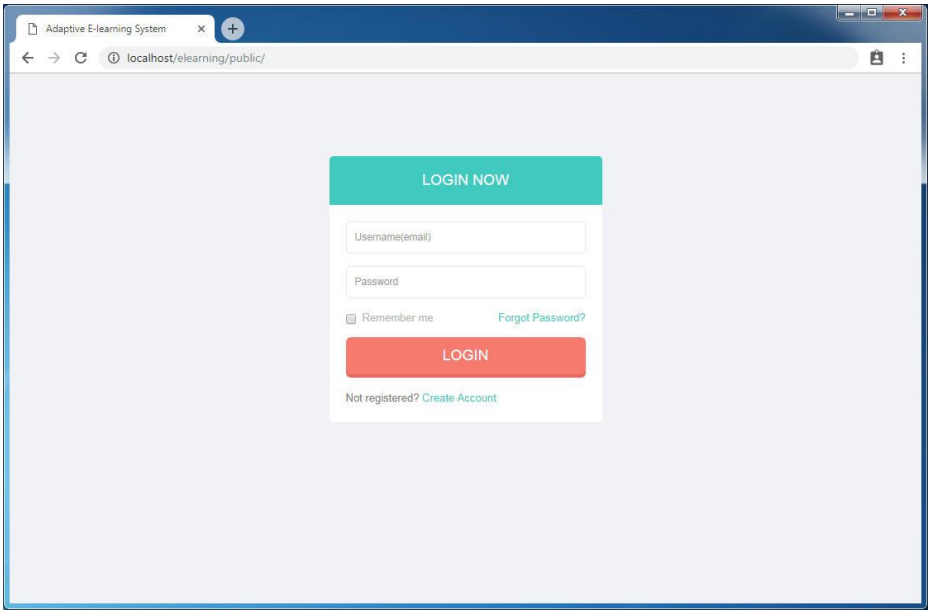


Figure 25. Login window

After a successful login, the student was given the learning style questionnaire (see Figure 26). They should answer 44 multiple-choice questions in order to get the learning style information.

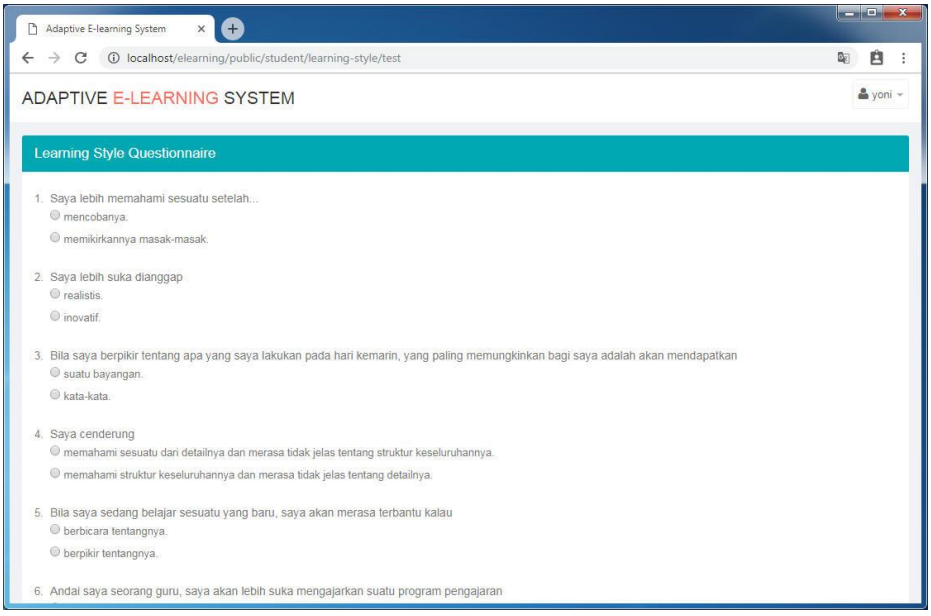


Figure 26. Learning style questionnaire window

In the next step, the students should take the pre-test. Figure 27 shows the interface appearance of the pre-test. This test consisted of 30 multiple-choice questions. This test aimed to evaluate the initial knowledge level of each student.

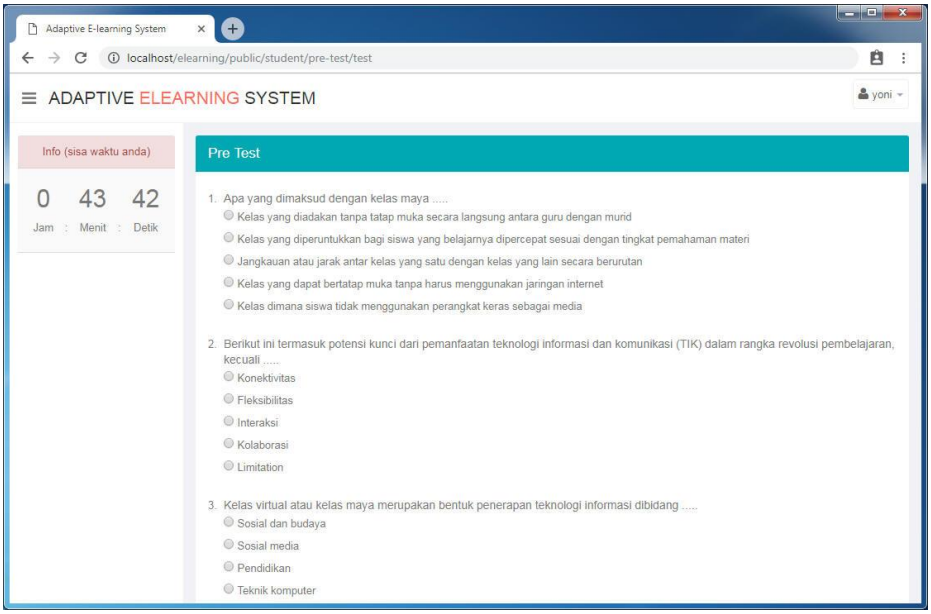


Figure 27. Pre-Test window

After the completion of the pre-test, the main window of an adaptive e-learning environment was revealed (see Figure 28).

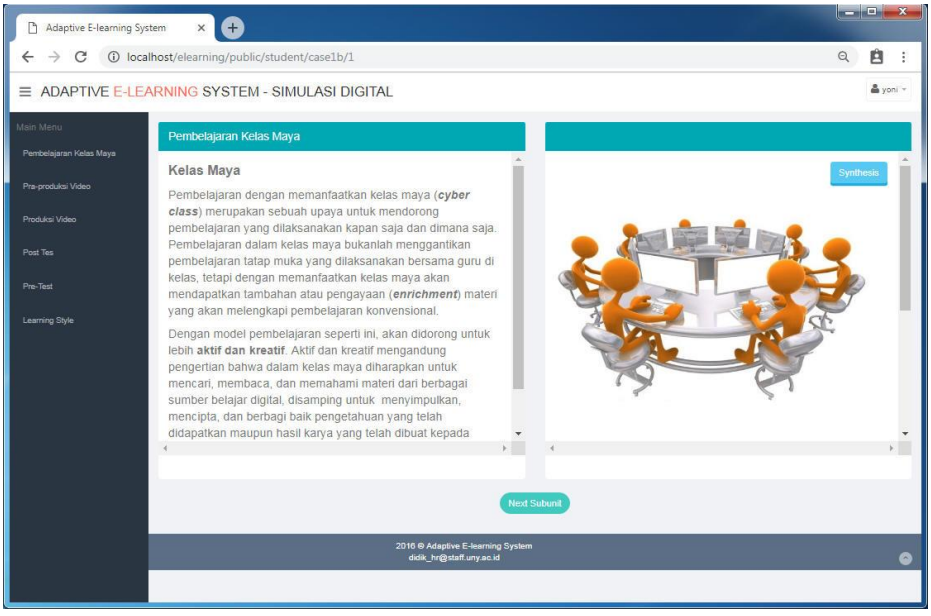


Figure 28. The main window of adaptive e-learning system

The instruction environment could be different for each student depends on the previous learning style and pre-test results. In this phase, the students individually learned and explored the material and learning environment offered by the e-learning system. The involvement of the teacher was focused merely on the discussion.

After experiencing the instruction system for a planned time, the students were asked to complete the post-test. This test functioned to measure the level of knowledge after the learning process through an adaptive e-learning system.

3.3.4.2. Data Collection

This study collects the data concerning 1) the initial knowledge level of the students, 2) the student's knowledge score after following the teaching process, and 3) the usability evaluation of the adaptive e-learning system. Those three data were collected from the experimental group and the control group. The experimental group is the group of students who took the learning process through the adaptive e-learning system. Meanwhile, the control group is the group of students who encountered traditional classroom learning.

The pre-test was given in the first session of the first meeting. The pre-test session lasted for 30 minutes. The control group took the pre-test in a paper-and-pencil format, whereas the experimental group took the pre-test through the web-based platform, which is available as one module in the adaptive e-learning system.

Furthermore, the same method was conducted for the post-test, where a paper-and-pencil format was distributed for the traditional classroom group, while a web-based post-test was given to the e-learning group. This test was carried out at the last session of the last meeting, and it took a maximum of 30 minutes to complete.

The usability evaluation data was collected just after the post-test session. For both groups, the usability evaluation was handed out in a paper-based format. All the students were given around 30 minutes to express their thought about the adaptive e-learning system through the usability questionnaire. The students should give one mark out of four point Likert scales for each statement. The group of students with adaptive e-learning experience could filled-out the questionnaire immediately after finishing the post-test. In contrast, the different treatment was given to the traditional classroom group since they never use the adaptive e-learning system. As such, they have been given three hours to experience the learning process through the e-learning system and, afterward, allowed to complete the usability questionnaire.

3.3.4.3. Data Analysis

Data analysis is the process of applying statistical techniques systematically using statistical tools in order to describe, illustrate, and evaluate data. In this study, the data analysis was

carried out using SPSS (Statistical Package for the Social Sciences) version 19. Before the analysis, the raw data were pre-processed by coding and tabulating to a data set.

The pre-test and post-test data were categorized into two conditions of response, with a right or wrong answer since both of those tests constructed in the multiple-choice model. As can be seen in Table 22, the right answer was coded as 1, while code 0 was for the wrong answer.

Table 22. The code of Pre- & Post-Test response

Pre- & Post-Test Response	Code
Right Answer	1
Wrong Answer	0

The usability evaluation data was constructed based on the Likert scale questionnaire with four possible answer options. In order to minimize the response and acquiescent bias, some questions were constructed in a negative wording format. The response was ranging from strongly disagree until strongly agree. For the positive wording statements, strongly disagree was coded as 1, disagree was coded as 2, agree and strongly agree were coded as 3 and 4, respectively. For the negative statements, they were coded in reverse order (see Table 23).

Table 23. The weight of Usability questionnaire response

Questionnaire Response	Weight of Response	
	Positive Statement	Negative Statement
Strongly Disagree	1	4
Disagree	2	3
Agree	3	2
Strongly Agree	4	1

After the process of response coding, the datasets were checked to assure all of the response data were coded correctly, and no typo mistakes. After that, the descriptive statistics were performed in order to quantitatively describe or summarize the basic features of the collected data. In this study, the measures of central tendency and variability were implemented. The measures of central tendency described the mean, median, and mode, whereas the measures of variability included the standard deviation

and the minimum-maximum values (Mann, 2010; Ross, 2017; Wonnacott & Wonnacott, 1990).

The main objective of this study is to indicate whether the adaptive e-learning system in the learning process can foster the learning outcome. Therefore, a comparison between the experimental group that used an adaptive e-learning system and the control group that experienced the traditional classroom setting was done. To address that, a t-test, the most commonly applied test for comparing two samples, was applied (Hinton, McMurray, & Brownlow, 2004; McKillup, 2011). The t-test requires interval or ratio dataset with continuous distributions and normally distributed population. Two t-test models were performed in this study. The independent t-test was conducted to determine the statistical difference between the experimental group and the control group concerning the knowledge test. Moreover, the paired t-test was used to determine the statistical difference in the pre- and post-test results in each group.

In this study, the acceptability of adaptive e-learning system through the usability evaluation was also analyzed. Three independent variables (usefulness, ease of use, ease of learning) and one dependent variable (satisfaction) involved in this usability evaluation were included. Hence, in order to know the relationship amongst those variables, the multiple linear regression was applied for the data analysis. Several prerequisites: 1) the variables used should meet normal distribution, 2) there was no multicollinearity, 3) there was no heteroscedasticity, and 4) autocorrelation should be taken into account before the multiple linear regression analysis (Hair et al., 2009). The F test was performed to analyze whether the independent variables simultaneously influence the dependent variable. Finally, the t-test was used to determine the effect of each independent variable on the dependent variable.

3.3.5. Ethical considerations

The main issue that should be considered in educational and social research is ethics. Ethics is the norms or standards to behave that distinguish between right and wrong. In educational research, one of the most important ethical concerns is related to the use of humans as a research subject, e.g., students, teachers, and head of the department, and a specific community such as a department and school. Accordingly, ethics should be taken into account to ensure the safety of human subjects during the research, and to ensure that human rights are not violated. Some of the essential ethical issues: (American Psychological

Association, 2002; Bell, 2010, 2014; Black, 2002; Cohen et al., 2002; Kitchener & Anderson, 2011; Piper, Simons, & others, 2005; Smith, 2003):

- Informed consent. This means that firstly, the researcher should inform the purpose of the research, the process in the research, and the consequences faced by participants. Second, the participated subject should give their permission to get involved in the research.
- Confidentiality and anonymity. These refer to the protection of privacy. The procedure guarantees the subjects not only to talk confidentially but also to refuse any publication related to any material that might harm them in any way.
- Pre-publication access. This allows the participants to read a draft report before the publication. It also allows the participants to look at the critical elements found in the research, but this offers more protection to the researcher than to participants.

In this study, the ethical issues were considered in order to eliminate the potential threat that may occur to the participants. The first stage to do is requesting formal permission from the school and its related institution to conduct the research. For this, the permission letter was received from the Office of Education, Youth, and Sport of Yogyakarta Province. Furthermore, the approval letter for doing a study was also accepted by the head of school. See Appendix H for the individual letters. Prior to the study, the students who were involved in this experimental research were informed briefly about the purpose of the research, expected duration, procedures, and the consequences that may arise. The students also had the right not to participate or to withdraw from the research once it has started. For confidentiality and privacy, all of the identities of participants were protected by providing the anonymity of the data in the report.

3.4. Summary

The first aim of this study is to design and develop the instructional system that can adapt to the student's preferences automatically. This can be conveniently constructed through the software engineering approach. Hence, it is not merely developing the educational system through the Instructional System Design (ISD) but also considering some strategies for software development as well. The selection of suitable approaches may lead to an effective and efficient process to meet the intended objectives.

The process began with the analysis of the learners, the course's subject, and the online medium infrastructures. Then, the process continued by the design of the learning workflow, the rules and procedures of adaptation, and the user interfaces. The next phase was to develop the instructional system based on the previous construction plan. Afterward, the educational system was implemented in the small-scale group of participants. All of the phases were followed by some evaluations, such as the functional test, expert evaluation, and user evaluation.

The second aim of this study is to determine whether the utilization of the adaptive e-learning system in the learning process could improve the learning outcome. This was conducted by employing the experimental research design containing two groups. One group known as an experimental group received a particular intervention, whereas the control group received no specific intervention. To compare both groups, a pre-test - post-test control group design was decided to be the appropriate method to address the study's purpose.

Some procedures followed by the research design were also considered. It included the sample selection, the treatment procedure for the experimental group and control group, as well as the data collection process and analysis. In general, two instruments including the knowledge test and the usability evaluation instrument were used in this study. The former was used to measure the knowledge level of the students, and the latter was conducted to assess the user perspective on the utilization of the instructional media. Lastly, the ethical issues, which comprised of informed consent, confidentiality and anonymity, and pre-publication access, should be considered as well in the study.

4
RESEARCH FINDINGS

4.1. Introduction

This chapter presents the findings of the research based on the statistical techniques in order to answer the research objectives. The first main research purpose is to examine the impact of the adaptive e-learning system used in the learning process whether it can increase the student's learning outcome. It can be seen considerably by comparing the group of students who learn by utilizing the e-learning system and the group in the traditional classroom setting. The statistical t-tests in both paired and independent methods are performed in order to address the comparison. The comparisons are conducted in several ways, i.e., 1) pre-test comparison between two groups, 2) post-test comparison between two groups, 3) pre- and post-test comparison within the experimental group, 4) pre- and post-test comparison within the control group, and 5) N-Gain comparison between two groups. The second aim of this study is to assess the respond of the students when accessing the adaptive instructional system by means of usability evaluation. It measures the level of usability of the instructional in four factors, i.e., usefulness, ease of use, ease of learning, and satisfaction. Furthermore, the correlation between those factors is explored. All findings from two concerns are presented in descriptive quantitative which are then analyzed in order to discover the phenomenon that emerged.

4.2. Knowledge Achievement in the Digital Simulation Course

This section focuses on the comparison between the group which exposed to the specific treatment by utilizing the adaptive e-learning system and the group which conducted the regular learning process. The comparison method is performed in terms of pre-test score, post-test score, and N-Gain score. It also explains the estimation and interpretation of

Effect Size (ES) that commonly used in quantifying the difference between the two compared groups.

4.2.1. Pre-Test Comparison between Two Groups

This comparison concentrates on the pre-test score between the experimental group and the control group. Those pre-test scores were obtained from the test which was conducted before the lesson started. This pre-test aimed to indicate the initial level of achievement of each student. Based on the data collected from the pre-test of both experimental and control groups, the mean score for each Bloom's taxonomy and its total mean score were then calculated. The comparison of the mean score of pre-test of those groups is presented in Figure 29.

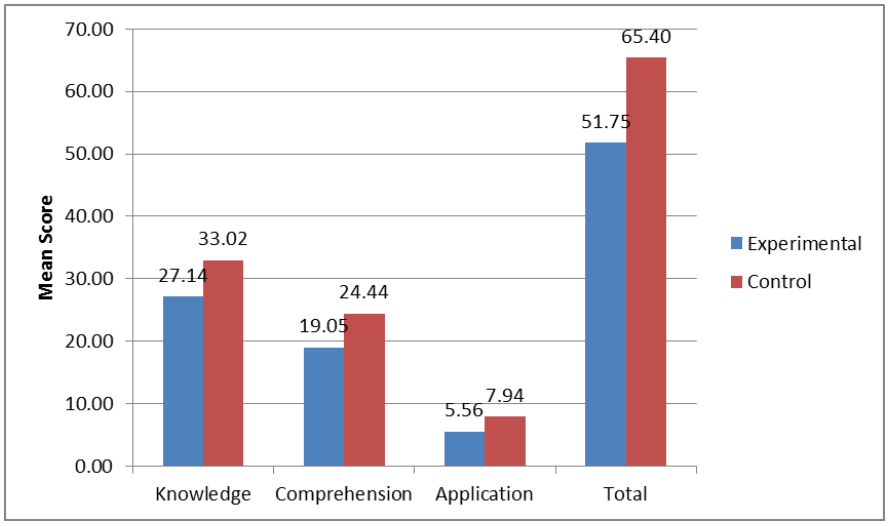


Figure 29. Comparison of two groups in terms of Pre-Test score

As can be seen in the graph above, the total mean score achieved by the students in the control group is higher than that achieved in the experimental group. The same situation arises in each Bloom's taxonomy, where the mean score for the aspects of knowledge, comprehension, and application in the control group is higher than that in the experimental group. The findings of these pre-test mean score comparison are interesting since in the normal situation, those groups should have the same level of initial knowledge.

In order to measure the differences level of prior knowledge of both groups, whether it is significant or not, the statistical comparison method was performed. The independent t-test was chosen because it is the general method to compare the score between two different groups. Prior to the t-test conducted, it should be assured that the data is

normally distributed and homogenous. Therefore the normality and homogeneity check should be implemented.

Table 24. The Normality Test of Pre-Test score of two groups

Group	Shapiro-Wilk		
	Statistic	df	p
Experimental Group	0.967	21	0.667
Control Group	0.931	21	0.142

The normality test was conducted by using the Shapiro-Wilk method. As shown in Table 24, it revealed that the p-values from both groups were exceeding the significant level (0.05). It indicated that the data from both groups were in the normal distribution.

Furthermore, the homogeneity test was implemented in order to check the homogeneity of both group's data. The result from Table 25 showed that the p-value is higher than the significant level (0.05). It is the indication that the data of both groups are homogenous.

Table 25. Homogeneity Test of Pre-Test score of both groups

Levene Statistic	df1	df2	p
2,696	1	40	0.108

After the normality and homogeneity test have performed and fulfilled the requirement, then the comparison t-test can be conducted. The statistical comparison was started by carrying-out the independent t-test of the mean score of total achievement from both groups. As seen in Table 26, the results showed that p-value is lower than the significant level (0.05). It means that there is a statistically significant difference in the mean score of the student's prior knowledge between those in the experimental group and those in the control group. It was postulated in the hypothesis that there was no statistical difference between the mean score of the experimental and control group. However, the finding showed that the hypothesis formulated was not accepted.

Table 26. Pre-Test comparison in terms of the total achievement scores

Group	N	Mean	Std. Deviation	t	p
Experimental Group	21	51.746	11.954	-4.386	0.000
Control Group	21	65.397	7.780		

As described previously that the achievement test was distributed on three taxonomy levels, therefore the comparison was also considering those three levels. First, in regards to the knowledge level, the pre-test mean scores of the students in the control group were significantly higher than those in the experimental group. It also showed that p-value (0.003) lower than the significant level (0.05). It indicated that there was a statistically significant difference in the mean score of the student's prior knowledge between those two groups in terms of the "knowledge" level.

Second, concerning the comprehension level, the pre-test mean scores of the students in the control group were significantly higher than those in the experimental group. The p-value (0.005) was lower than the significant level (0.05). It implied that there was a statistically significant difference in the mean score of the student's prior knowledge between those two groups in terms of the "comprehension" level.

The third level (application) also showed the same finding where the pre-test mean scores of the students in the control group were significantly higher than those in the experimental group. The p-value (0.004) was also lower than the significant level (0.05). It confirmed that there was a statistically significant difference in the mean score of the student's prior knowledge between those two groups in terms of the "application" level.

The t-test comparison results for three taxonomy levels can be seen in Table 27 below.

Table 27. Pre-Test comparison in terms of the achievement scores for each taxonomy level

Level	Group	Mean	Std. Deviation	t	p
Knowledge	Experimental Group	27.143	6.262	-3.162	0.003
	Control Group	33.016	5.764		
Comprehension	Experimental Group	19.048	6.249	-2.992	0.005
	Control Group	24.444	5.409		
Application	Experimental Group	5.556	2.855	-3.012	0.004
	Control Group	7.937	2.230		

Based on the data presented on the bar-chart in Figure 29, it can be summarized that the student's prior knowledge for those who experienced the learning process through the adaptive e-learning system had the mean score lower than those who were exposed the regular training system. Through the independent t-test, it is also confirmed that the initial achievement score between experimental and control group has a statistically significant

difference in each cognitive level as well as in total achievement score. Therefore, the hypotheses were verified as follows:

H_1: There is a statistically significant difference between the experimental group and control group in terms of the pre-test score of the total achievement.

$H_{1.1}$: There is a statistically significant difference between the experimental group and control group in terms of the pre-test score of the knowledge-level.

$H_{1.2}$: There is a statistically significant difference between the experimental group and control group in terms of the pre-test score of the comprehension-level.

$H_{1.3}$: There is a statistically significant difference between the experimental group and control group in terms of the pre-test score of the application-level.

4.2.2. Post-Test Comparison between Two Groups

The comparison in this section focuses on the post-test score between the experimental group and the control group. The post-test score was collected by giving the achievement test to the students after finished studying some subject units. This comparison aims to measure the difference in student's achievement from two different treatment groups. It is hypothesized that the post-test mean score of the students in the experimental group is exceeding those in the control group.

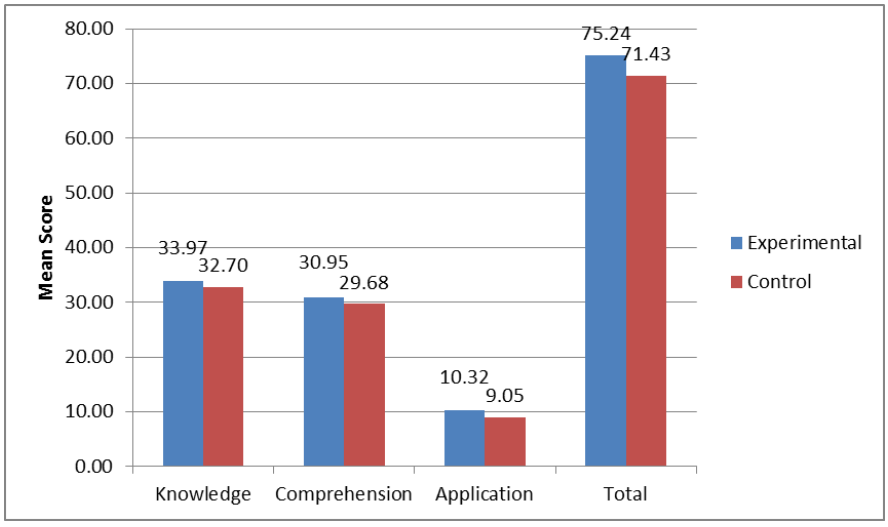


Figure 30. Comparison of both groups in terms of Post-Test score

As shown in Figure 30 below, in general, the students who studied in the experimental group scored higher achievement than those who participated in the control group. The total mean score and including for each mean score of knowledge, comprehension, and

application aspects of the experimental group were surpassing those in the control group. It implied that the strategy of utilizing the adaptive e-learning in the learning process in the experimental group had successfully conducted. However, it needs further investigation whether the better achievement in the experimental group was statistically significant.

Accordingly, the independent t-test was conducted in order to compare the post-test mean scores between those two groups. Before that, the normality and homogeneity test was performed as required for data preparation. The Shapiro-Wilk test was implemented for the normality test. The p-value from Table 28 was higher than the significant level (0.05). It revealed that the data of both the experimental and control group were in the normal distribution.

Table 28. The Normality Test of Post-Test score of both groups

Group	Shapiro-Wilk		
	Statistic	df	p
Experimental Group	0.939	21	0.213
Control Group	0.948	21	0.313

The next step was performing the homogeneity test in order to check the homogeneity of data. The result from Table 29 showed that the p-value was greater than the significant level (0.05). It indicated that the data of both groups were homogenous.

Table 29. Homogeneity Test of Post-Test score of both groups

Levene Statistic	df1	df2	p
2.400	1	40	0.129

After completing the normality and homogeneity test, the independent t-test can be implemented. It can be seen in Table 30 that the total mean score of students in the experimental group (75.238) was slightly higher than those in the control group (71.428). However, the p-value was higher than the significant level (0.05). Consequently, this result illustrated that there was no statistically significant difference between both groups in terms of the post-test mean score. It confirmed that the hypothesis assumed was rejected.

Table 30. Post-Test comparison in terms of the total achievement scores

Group	N	Mean	Std. Deviation	t	p
Experimental Group	21	75.238	7.271	1.425	0.162
Control Group	21	71.428	9.864		

The comparison in detail in each taxonomy level was also conducted, particularly for the three lower levels, i.e., knowledge, comprehension, and application. As seen in Table 31, regarding the knowledge level, the post-test mean scores of the students in the experimental group were significantly higher than those in the control group. Nonetheless, the p-value (0.526) was higher than the significant level (0.05). This result indicated that there was no statistically significant difference in the mean score of the student's achievement after treatment between those two groups in terms of the "knowledge" level.

Concerning the comprehension level, the result showed that the post-test mean scores of the students in the experimental group were relatively higher than those in the control group. However, the p-value (0.236) produced a higher score than the significant level (0.05). It pointed out that there was no statistically significant difference in the mean score of the student's achievement after treatment between those two groups in terms of the "comprehension" level.

In terms of the application level, the same finding was revealed where the post-test mean scores of the students in the experimental group were slightly greater than those in the control group. But, the p-value (0.134) was higher than the significant level (0.05). It confirmed that there was no statistically significant difference in the mean score of the student's achievement after treatment between those two groups in terms of the "application" level.

Table 31. Post-Test comparison in terms of the achievement scores for each taxonomy level

Level	Group	Mean	Std. Deviation	t	p
Knowledge	Experimental Group	33.968	5.833	0.640	0.526
	Control Group	32.699	6.962		
Comprehension	Experimental Group	30.952	3.357	1.203	0.236
	Control Group	29.683	3.481		
Application	Experimental Group	10.317	2.964	1.528	0.134
	Control Group	9.048	2.390		

Based on the findings, the interesting point can be noted that though the student's achievement score for those who learned in the experimental group had a higher mean score than those who learned in the control group, however, it is not proved statistically significant difference. Therefore, the hypotheses were clarified as follows:

H_2: There is no statistically significant difference between the experimental group and control group in terms of the post-test score of the total achievement.

$H_{2.1}$: There is no statistically significant difference between the experimental group and control group in terms of the post-test score of the knowledge-level.

$H_{2.2}$: There is no statistically significant difference between the experimental group and control group in terms of the post-test score of the comprehension-level.

$H_{2.3}$: There is no statistically significant difference between the experimental group and control group in terms of the post-test score of the application-level.

4.2.3. Pre- and Post-Test Comparison within the Experimental Group

This section describes the comparison between pre- and post-test score for each student in the experimental group. The purpose of this comparison is to measure whether there is an improvement after following the treatment. The paired t-test was used to investigate the changes score between the pre- and post-test score.

As seen in Table 32, on average, the post-test score was significantly higher than the pre-test score. It also showed that the p-value was less than the significant level. This meant that there was a significant improvement in terms of student's achievement in the experimental group.

Table 32. Pre- and Post-Test comparison within the experimental group in terms of the total achievement scores

Test Stage	N	Mean	Std. Deviation	t	p
Pre-Test	21	51.746	11.954	-12.433	0.000
Post-Test	21	75.238	7.270		

Concerning the knowledge-level, the p-value (0.000) was lower than the significant level (0.05). It indicated that there was a significant difference between the pre-test mean score and the post-test mean score. It also displayed a significant improvement in the achievement score, where the post-test score (33.968) was higher than the pre-test score

(27.143). In regards to the comprehension-level, the t-test value showed that the difference between the pre-test mean score and the post-test mean score was statistically significant ($p < 0.05$). The finding also indicated that there was a significant improvement in the achievement score, where the post-test score (30.952) was higher than the pre-test score (19,048). Focus on the application-level, it pointed out that there was a significant difference between the pre-test mean score and the post-test mean score where the p-value was lower than the significant level ($p < 0.05$). The result also pinpointed that there was a significant improvement in the achievement score, where the post-test score (10.317) was higher than the pre-test score (5.556).

Table 33. Pre- and Post-Test comparison within the experimental group in terms of the achievement scores for each taxonomy level

Level	Test Stage	Mean	Std. Deviation	t	p
Knowledge	Pre-Test	27.143	6.262	-5.129	0.000
	Post-Test	33.968	5.833		
Comprehension	Pre-Test	19.048	6.249	-9.360	0.000
	Post-Test	30.952	3.357		
Application	Pre-Test	5.556	2.855	-6.086	0.000
	Post-Test	10.317	2.964		

Figure 31 portrays a better overview of the improvement achieved by the students in the experimental group. The bar-charts showed in Figure 31 depict the mean score before and after the treatment. It can be seen that the total mean score obtained in the post-test is much higher than the pre-test. The total score after the treatment is around 50% above the total score before treatment. Each level of Bloom's taxonomy; i.e., knowledge, comprehension, and application also reaches a higher score for the post-test compared with the pre-test.

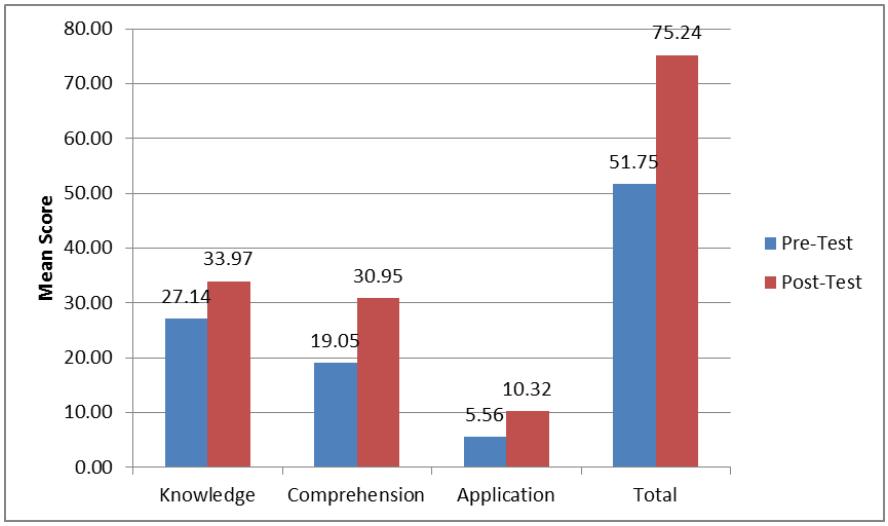


Figure 31. Comparison of Pre- and Post-Test score in the experimental group

Based on the results obtained, it can be highlighted that in all levels of taxonomy, the post-test mean scores were above the pre-test mean scores. This indicated that the student's achievement that used the adaptive e-learning system in the learning process was improved significantly in terms of the knowledge-level, the comprehension-level, and the application-level. As a summary, the following hypotheses were verified:

H_3: There is a statistically significant difference between the pre-test and post-test within the experimental group in terms of the mean score of the total achievement.

$H_{3.1}$: There is a statistically significant difference between the pre-test and post-test within the experimental group in terms of the mean score of the knowledge-level.

$H_{3.2}$: There is a statistically significant difference between the pre-test and post-test within the experimental group in terms of the mean score of the comprehension-level.

$H_{3.3}$: There is a statistically significant difference between the pre-test and post-test within the experimental group in terms of the mean score of the application-level.

4.2.4. Pre- and Post-Test Comparison within the Control Group

This section discusses the comparison between the pre-test score and the post-test score achieved by students in the control group. The paired t-test was adopted in order to measure whether there was a difference between those achievement scores.

As indicated by the lower p-value (0.006) in Table 34 compared with the significance level (0.05), it can be noted that there was a significant difference between the pre- and post-

test score. It also found that the post-test mean score was greater than the pre-test mean score. It meant that there was a significant improvement in the student's achievement before and after the class meeting.

Table 34. Pre- and Post-Test comparison within the control group in terms of the total achievement scores

Test Stage	N	Mean	Std. Deviation	t	p
Pre-Test	21	65.397	7.780	-3.077	0.006
Post-Test	21	71.429	9.864		

When the comparison conducted on three lower taxonomy levels, i.e., knowledge, comprehension, and application level, they showed the same conclusion. With regards to the knowledge level, it showed no significant improvement in the student's achievement. It proved that the post-test mean score was lower than the pre-test mean score and the p-value was above the significant level (0.05). Focus on the comprehension-level, it showed a significant improvement in the student's achievement ($p < 0.05$). It indicated by the higher post-test mean score compared with the pre-test mean score. The same finding also happened in the application-level where the post-test mean score was exceeding the pre-test mean score ($9.048 > 7.937$). Nevertheless, the difference between those is not statistically significant ($p > 0.05$). For the detail results can take a look in Table 35.

Table 35. Pre- and Post-Test comparison within the control group in terms of the achievement scores for each taxonomy level

Level	Test Stage	Mean	Std. Deviation	t	P
Knowledge	Pre-Test	33.016	5.764	0.170	0.867
	Post-Test	32.698	6.962		
Comprehension	Pre-Test	24.444	5.409	-5.284	0.000
	Post-Test	29.683	3.481		
Application	Pre-Test	7.937	2.230	-1.673	0.110
	Post-Test	9.048	2.390		

The chart in Figure 32 shows the comparison between the score before and after the regular class meeting. In general, the total mean score after following the learning process is higher than the initial stage.

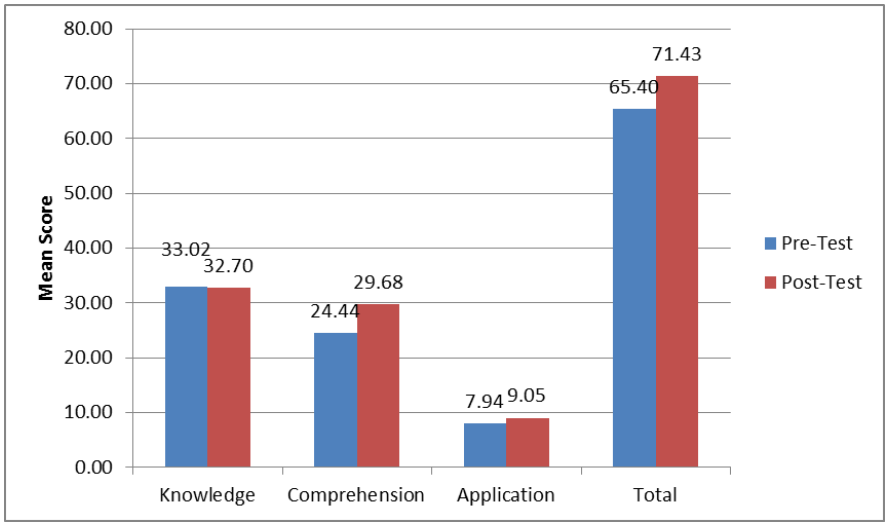


Figure 32. Comparison of Pre- and Post-Test score in the control group

The data shows 71.43 for the post-test score compared with 65.40 for the pre-test score. It is not so high, but there are approximately 6 points of improvement. In terms of Bloom's taxonomy, the post-tests in comprehension and application level are reached more top than scores in the pre-tests. The different situation is revealed in the knowledge level, where the post-test score reaches below the pre-test score.

Based on the results presented, one can be noticed that the total student's achievement in the post-test was significantly increased than the student's achievement in the pre-test. To summarize, the detailed hypotheses were verified as follows:

H_4: There is a statistically significant difference between the pre-test and post-test within the control group in terms of the mean score of the total achievement.

$H_{4.1}$: There is no statistically significant difference between the pre-test and post-test within the control group in terms of the mean score of the knowledge-level.

$H_{4.2}$: There is a statistically significant difference between the pre-test and post-test within the control group in terms of the mean score of the comprehension-level.

$H_{4.3}$: There is no statistically significant difference between the pre-test and post-test within the control group in terms of the mean score of the application-level.

4.2.5. N-Gain Score Comparison between Two Groups

In previous sections, it analyzed the comparison of pre-test score and post-test score between two different treatment groups. In this section, it takes a different approach and looks at the changes scores from the pre-test and post-test scores. The focus is on the

improvement or gain score analysis from pre-test to post-test. The general approach for analyzing the gain is commonly called normalized gain (N-Gain), which is introduced by Hake (1999). He defined normalized gain "as a rough measure of the effectiveness of a course in promoting conceptual understanding." This approach has become the standard measure for reporting the changes scores between pre- and post-treatment in the experimental-based research. This normalized gain has a benefit for measuring a strong differentiation between learning strategies for diverse student preferences and varied initial knowledge states.

There are two ways of calculating N-Gain. The first way is by calculating firstly the average pre-test score and the average post-test score of the student's achievement in one group, then take the N-Gain. This formulation is called a Gain of averages and a standard way following the definition of Hake. The second alternative is by firstly calculating the N-Gain for each student's score, then takes the average of N-Gain collected. It is called an Average of gains and the most commonly used by many researchers for N-Gain calculation. Hake (1999) and Bao (2006) reported that those two ways of calculation are not produced a significant difference for large classes, but may differ a little bit for small classes.

The latter was chosen for this study because it is more appropriate for the next comparison t-test. The N-Gain is formulated as follows:

$$N\text{-}Gain_{ave} = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}}$$

which:

$N\text{-}Gain_{ave}$ = Average of N-Gain

S_{post} = Score from Post-Test

S_{pre} = Score from Pre-Test

S_{max} = Score maximum

Figure 33 illustrates the bar-chart in three different groups. The first group talks about the comparison between the experimental and control group in terms of the pre-test score. The second bar-chart which located in the middle depicts the comparison between the experimental and control group with regards to the post-test score. And the last bar-chart describes the N-Gain score in percentages between the experimental and control group.

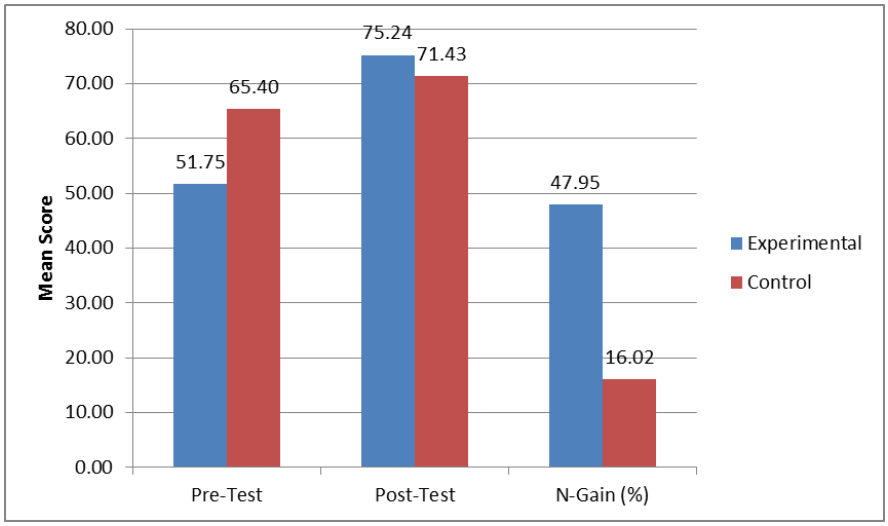


Figure 33. Comparison of both groups in terms of Pre-Test, Post-Test, and N-Gain score

It can be seen that though there is an improvement in terms of the achievement score for both the experimental and control group. However, it is interesting to note that, the available improvement obtained is much higher in the experimental group compared with the control group. The N-Gain comparison has also confirmed this finding. It shows that the N-Gain in the experimental group is much higher than in the control group. The N-Gain of the experimental group is almost three times of the control group.

Hake (1999) was also made a categorization of the normalized gain at certain levels. As seen in Table 36, for the N-Gain below 0.3 is described as “Low”, for the N-Gain in between 0.3 and 0.7 is defined as “Medium”, and for the N-Gain above 0.7 is represented as “High”.

Table 36. N-Gain categorization

N-Gain	Gain Category
$g < 0.3$	Low Gain
$0.3 \leq g \leq 0.7$	Medium Gain
$g > 0.7$	High Gain

Referring to the gain categorization that can be seen in Table 36 above, it can be summarized that the normalized gain on the experimental group in terms of the total achievement score is in the medium level compared with the low category of the normalized gain in the control group. As detailed in Table 37 below, focused on the knowledge aspect, for both the experimental and control group are in the same category, those are in the low gain category. For the comprehension aspect, though the normalized

gain of the experimental group reaches almost twice as the control group has, both groups in the same category (medium gain).

Table 37. Gain category for each taxonomy level and for total achievement

Level	Group	Mean	Gain Category
Knowledge	Experimental Group	0.262	Low
	Control Group	-0.106	Low
Comprehension	Experimental Group	0.661	Medium
	Control Group	0.380	Medium
Application	Experimental Group	0.591	Medium
	Control Group	0.079	Low
Total	Experimental Group	0.479	Medium
	Control Group	0.160	Low

The different situation happens in the application aspect, where the experimental group has a very high N-Gain than the control group has. The improvement in the experimental group is around seven times compared with the control group. The normalized gain of the experimental group is positioned in the medium category and the control group is classified in the low category.

In order to assess the significant difference between the experiment and control group in terms of the N-Gain score, the independent t-test should be performed. Before that, the data involved should meet the normal distribution. To deal with the normality test, the Shapiro-Wilk was selected. Table 38 shows the results of the normality test. The p-value for both the experimental and control group are exceeding the significant level (0.05). It indicates that the data in both the experimental and control group are in the normal distribution. Since the normality test fulfilled the criteria, thus the t-test can be performed.

Table 38. The Normality Test of N-Gain score of both groups

Group	Shapiro-Wilk		
	Statistic	df	p
Experimental Group	0.962	21	0.564
Control Group	0.923	21	0.099

The independent t-test was managed in order to compare the gain score of total achievement from both groups. The results as shown in Table 39 displayed that the mean

of the gain score in the experimental group was significantly greater than that in the control group. The table also displayed that p-value was below a significant level (0.05). It indicated that there was a statistically significant difference in the gain score of the students between those in the experimental group and those in the control group. In conclusion, the hypothesis formulated was accepted.

Table 39. N-Gain score comparison in terms of the total achievement scores

Group	N	Mean	Std. Deviation	t	p
Experimental Group	21	0.479	0.113	4.856	0.000
Control Group	21	0.160	0.279		

The gain score analysis was also conducted for each level of cognitive taxonomy. In regards to the knowledge level, the gain scores of the students in the experimental group were significantly higher than those in the control group. It also showed that p-value (0.009) lower than the significant level (0.05). It indicated that there was a statistically significant difference in the gain score of the students between those two groups in terms of the "knowledge" level.

Focus on the comprehension level, the gain scores of the students in the experimental group were significantly higher than those in the control group. The p-value (0.001) was lower than the significant level (0.05). It implied that there was a statistically significant difference in the gain score of the students between those two groups in terms of the "comprehension" level.

Specific in the application level, it also showed the same situation where the gain scores of the students in the experimental group were significantly higher than those in the control group. The p-value (0.006) was also lower than the significant level (0.05). It confirmed that there was a statistically significant difference in the gain score of the students between those two groups in terms of the "application" level.

Table 40. N-Gain score comparison in terms of the achievement scores for each taxonomy level

Level	Group	Mean	Std. Deviation	t	P
Knowledge	Experimental Group	0.262	0.311	2.756	0.009
	Control Group	-0.106	0.527		
Comprehension	Experimental Group	0.661	0.194	3.575	0.001
	Control Group	0.380	0.305		

Application	Experimental Group	0.591	0.489	2.925	0.006
	Control Group	0.079	0.636		

Based on the findings of the independent t-test of N-Gain comparison, it can be concluded that there was a more significant improvement of achievement between the students who experienced the learning process through the adaptive e-learning system than the students who learned in the traditional school setting. Therefore, the hypotheses were verified in detail as follows:

H_5: There is a statistically significant difference between the experimental group and control group in terms of the gain score of the total achievement.

$H_{5.1}$: There is a statistically significant difference between the experimental group and control group in terms of the gain score of the knowledge-level.

$H_{5.2}$: There is a statistically significant difference between the experimental group and control group in terms of the gain score of the comprehension-level.

$H_{5.3}$: There is a statistically significant difference between the experimental group and control group in terms of the gain score of the application-level.

4.2.6. Estimation and Interpretation of Effect Size (ES)

Effect Size is a simple way to quantify the size of the difference between two groups. In this study, it will compute the difference of the gain score between experimental group and control group. Since this study is related to the population mean and standard deviation, one well-known way to measure the Effect Size is using *Cohen's d* method. *Cohen's d* is determined by calculating the mean difference between two groups and then dividing the result by the pooled standard deviation. The following is the formula to get the Effect Size based on *Cohen's d* method.

$$Cohen's\ d = \frac{(M_2 - M_1)}{SD_{pooled}}$$

in which:

$$SD_{pooled} = \sqrt{\frac{({SD_1}^2 + {SD_2}^2)}{2}}$$

where:

M_1 = Mean group 1

M_2 = Mean group 2

SD_1 = Standard Deviation group 1

SD_2 = Standard Deviation group 2

Cohen (2013) provided the rule of thumb to interpret effect sizes. He suggested to divide the effect sizes into 3 level of interpretation; d = 0,2 defined as small, d = 0,5 interpreted as medium, and d = 0,8 described as large.

Table 41. Rule of thumb of Effect Size

d	**Effect Size**
0.01	Very small[b]
0.2	Small[a,b]
0.5	Medium[a,b]
0.8	Large[a,b]
1.20	Very Large[b]
2.0	Huge[b]

[a] Cohen (2013); [b] Sawilowsky (2009)

Sawilowsky (2009) revised the Cohens' rules of thumb for effect sizes by defining d = 0.01 as very small, d = 0.2 as small, d = 0.5 as medium, d = 0.8 as large, d = 1.2 as very large, and d = 2.0 as huge. See Table 41 to get a clear picture of the rule of thumb of Effect Size.

Table 42 shows the result of the Effect Size calculation from the total achievement score. An effect size of 2.002 means that the score of the average person in the experimental group is 2.002 times the standard deviations above the average person in the control group, and it also indicates that the mean of the experimental group is at the 98th percentile of the control group (Large/Huge effect).

Table 42. Effect Size in terms of the N-Gain scores

Group	N	Mean	Std. Deviation	Cohen's d	Interpretation
Experimental Group	21	23.492	8.659	2.002	Large effect[a]
Control Group	21	5.873	8.938		Huge effect[b]

[a] Cohen (2013)
[b] Sawilowsky (2009)

Meanwhile, the Effect Size for each taxonomy level can be seen in Table 43. With regards to the knowledge level, the Effect Size of 0.961 indicates that the mean of the treated group is at the 82nd percentile of the untreated group (Large effect). Concerning the comprehension level, the Effect Size of 1.276 indicates that the mean of the treated group is at the 88th percentile of the untreated group (Large/Very large effect). In terms of the application level, the Effect Size of 1.097 indicates that the mean of the treated group is at the 96th percentile of the untreated group (Large effect).

Table 43. Effect Size in terms of the N-Gain scores for each taxonomy level

Level	Group	Mean	Std. Deviation	Cohen's d	Interpretation
Knowledge	Experimental Group	6.825	6.099	0.961	Large effect
	Control Group	-0.318	8.557		
Comprehension	Experimental Group	11.905	5.828	1.276	Large effect[a]
	Control Group	5.238	4.543		Very large effect[b]
Application	Experimental Group	4.762	3.586	1.097	Large effect
	Control Group	0.952	3.357		

[a] Cohen (2013)
[b] Sawilowsky 2009)

4.3. Usability Evaluation of the Adaptive E-learning System

This section focuses on the investigation to estimate the level of usability of the instructional application developed. First, it gauges the four aspects of usability assessment and interprets the finding through some validation strategies. The second part is exploring the relationships amongst the variables, particularly between the independent and dependent variables.

4.3.1. Usability Measurement Score

The data was collected by distributing the USE Questionnaire to the participants who experienced the learning process through the adaptive e-learning system. The participants were asked to express their opinion for each statement in the questionnaire by choosing one out of four point Likert scale. The answers are tabulated and counted in order to get the mean score for each variable on the questionnaire. As suggested by Nielsen (1994), it is necessary to get the mean score in order to describe the result of the usability measurement. In this study, the final mean scores of each variable (usefulness, ease of use,

ease of learning, and satisfaction) are 3.262, 3.228, 3.360, and 3.230 respectively (see Table 44).

Table 44. Mean score and 0-100 score of the Usability evaluation

Variables	Mean Score	0 - 100 Score
Usefulness	3.262	75.407
Ease of Use	3.228	74.255
Ease of Learning	3.360	78.659
Satisfaction	3.230	74.332
Average Score	3.270	75.663

The next important step is interpreting those mean scores in order to decide whether each measurement variable in the criteria is acceptable. There are many justification methods, including the one proposed by Babbitt and Nystrom (1989). They simply categorized the mean scores as accepted or unaccepted based on the dichotomously justification to the direction of response. If the direction of response is going to the degree of agree or strongly agree, the measurement in such variable is acceptable. Otherwise, if the response leaning towards the opposite one (disagree or strongly disagree), it indicates that the assessment is unacceptable.

Another similar method would be the one conducted by Marreez et al. (2013). Hereby, the Likert score is converted into “binomial data” by deciding the acceptance and rejection categories according to agree and disagree responses from the respondents. This method categorizes score 4 (strongly agree) and score 3 (agree) as accepted and score 2 (disagree) and score 1 (strongly disagree) as rejected or not accepted.

Debevc and Bele (2008) assessed the usability measurement in a different way. They first converted the mean scores into a typical school score of the range 0 - 100. As can be seen in Table 44, the converted scores of usefulness, ease of use, ease of learning, and satisfaction are 75.407, 74.255, 78.659, and 74.332, respectively. Then, they set the positive limit of acceptable criteria to 50 (Debevc & Bele, 2008). When the score is exceeding the threshold 50, it means acceptable and otherwise, unacceptable or unsatisfactory.

From the aforementioned results, it can be then decided based on the criteria recommended by those researchers. Two methods: the dichotomously (Babbitt & Nystrom, 1989) and binomial method (Marreez et al., 2013) have a similar calculation strategy, it can

be concluded that the adaptive e-learning system is well accepted in general. The mean score of each variable is at least 3. It indicates that those scores are in the acceptable range. The average score of all variables is above 3, which fulfills the acceptable criteria.

When the judgment of usability evaluation takes the method conducted by Debevc et al. (2008) into consideration, it can be concluded that the instructional system is well accepted and satisfactory. Focused on the 0 - 100 score column in Table 44, it shows that all of the scores in 4 variables exceed 50; it means that the usefulness, ease of use, ease of learning, and satisfaction are accepted. The average score from 4 variables, as representative of usability, is 75.663, which also higher than 50. Thus, the usability of the proposed learning system is accepted by the user. The average score 75.663 of the USE questionnaire collected from the students brings to the assumption that 75.663 percent 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 75.663 students are satisfied with the system and fell the system is accepted to be used for its purpose.

4.3.2. Multiple Linear Regression Prerequisites

While it is important to interpret the usability measurement score either on each variable or on average score, it is also urgent to analyze the relationship amongst the measurement variables on the questionnaire. As stated by Hair et al. (2009), multiple linear regression analysis, also known simply as multiple regression, is a statistical technique that can be used to analyze the relationship between two or more independent variables and a single dependent variable. The regression analysis gives a result in the regression equation or regression model. Before the analysis of multiple linear regression, there are classical assumptions that should be tested related to the measurement variables used. These tests should be taken into account in order to make the results more valid and trustworthy. Ho (2006) mentioned that the variables used in the multiple regression analysis should meet the requirements of a normal distribution, there is no multicollinearity, there is no heteroscedasticity, and autocorrelation. The following will explain several key assumptions investigation:

4.3.2.1. Multivariate Normality Test

The first assumption, the variables should be normally distributed. Non-normally distributed variables (highly skewed or kurtotic variables, or variables with substantial

outliers) can distort the relationship and significance tests. This assumption may be detected by constructing a residual data plot and then visually checked to see whether the distribution approximates the normal distribution.

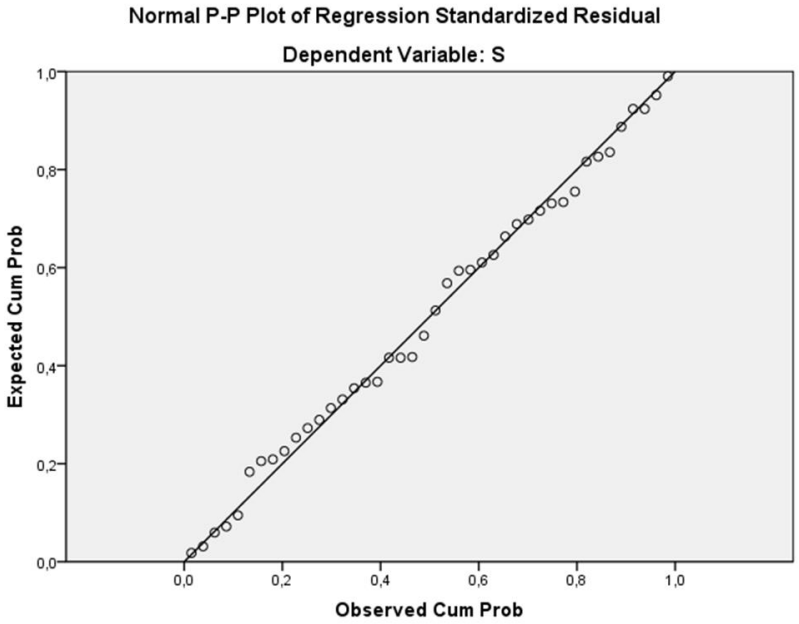


Figure 34. Normality Test data plot

As shown in Figure 34, there is a diagonal line and a bunch of little circles. The data is normally distributed if the points are located along and follow the diagonal line. In general, the lack of significant deviations does not jeopardize the normal distribution assumption. Since this criterion is met by the residual data plotted in Figure 34, it indicates that the data is in a normal distribution.

4.3.2.2. 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 amongst the independent variables. Multicollinearity can be observed from the Variance Inflation Factor (VIF) and Tolerance. The criterion of 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). The Tolerance values that are less than 0.1 or VIF values are greater than 10 may merit further investigation (Ho, 2006). Based on the multicollinearity test as shown in Table 45, it shows that VIF values for each independent variable are smaller than 10 in which usefulness, ease of use, and ease of learning are 2.037, 2.668, and 2.104 respectively. The

Tolerance values for usefulness (0.491), ease of use (0.375), and ease of learning (0.475) are also met the criteria which are above 0.1. Hence, it can be concluded that all independent variables are free of multicollinear or no correlation exists between each variable.

Table 45. Multicollinearity Test table

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	**VIF**
1	(Constant)		
	Usefulness	0.491	2.037
	Ease of Use	0.375	2.668
	Ease of Learning	0.475	2.104

a. Dependent Variable: Satisfaction

4.3.2.3. Heteroscedasticity Test

The last assumption of multiple linear regression is homoscedasticity. Homoscedasticity defines a situation in which there is the same error (homogeneous) across all values in the relationship between the independent variables and the dependent variable. Meanwhile, when there is a violation on the homoscedasticity, it can assume that heteroscedasticity is occurred in the data.

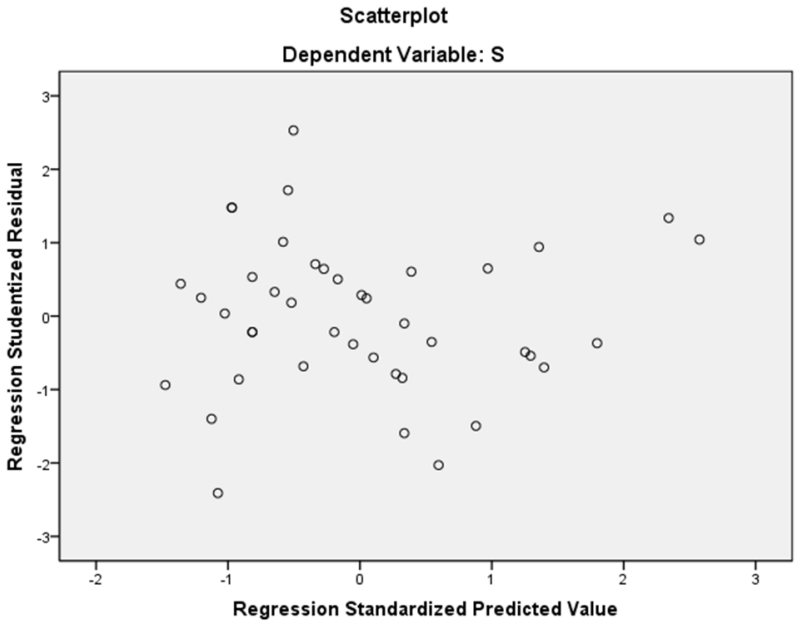


Figure 35. Homoscedasticity Test scatterplot

One of the best ways to check this assumption is by a 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) (Osborne & Waters, 2002). There should be no specific pattern in the distribution, such as a bow-tie or cone shape. The graph in Figure 35 shows that the scatterplot of residuals meets the criteria mentioned earlier. Thus, it can be concluded that there is no heteroscedasticity in the regression model or the model fulfills homoscedasticity.

4.3.3. Multiple Linear Regression Analysis

The classical assumptions tests have conducted previously in order to fulfill the requirement before doing further multiple regression analysis. As a result, it can be summarized that all model assumptions satisfy the criteria. Therefore, multiple linear regression analysis can be performed. In this section, two different tests are explained, i.e., F Test and t-Test. The F Test is used to investigate the relationship of the independent variables simultaneously to the dependent variable. Meanwhile, t-Test is used to examine the relationship of the independent variables partially to the dependent variable.

4.3.3.1. Simultan F Test

The F Test in this section aims to analyze whether the independent variables simultaneously influence the dependent variable. As shown in the ANOVA table (see Table 46), the Sig. value is less than the significant level 0.05 (0.000 < 0.05) and the F statistic is greater than F table (18.662 > 2.852). This finding indicates that the independent variables (usefulness, ease of use, and ease of learning) simultaneously influence the dependent variable (satisfaction).

Table 46. F Test table

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	104.911	3	34.970	18.662	0.000[a]
	Residual	71.208	38	1.874		
	Total	176.119	41			

a. Predictors: (Constant), Usefulness, Ease of Use, Ease of Learning

b. Dependent Variable: Satisfaction

Based on the above F Test analysis, the hypothesis can be verified as follows:

H_6: The independent variables (usefulness, ease of use, and ease of learning) all together are statistically significant influence the dependent variable (satisfaction).

4.3.3.2. Partial t-Test

The t-Test in this section is conducted in order to test the statistical significance of each of independent variables whether those individually influence the dependent variable. The t-value and corresponding p-value are located in the "t" and "Sig." columns as shown in Table 47 below. It can be seen that the first independent variable (usefulness) has Sig. value 0.125 which is higher than the significance level (0.05) and t value (1.568) is lower than t table (2.024). This states that usefulness has no significant influence on satisfaction. The second independent variable (ease of use) has a significant influence on satisfaction in which the Sig. value (0.001) is less than the significance level (0.05) and t value (3.804) exceeds t table value (2.024). Meanwhile, the last independent variable (ease of learning) has Sig. value 0.654 above the significance level (0.05). It indicates that ease of learning has no significant influence on satisfaction.

Table 47. t-Test table

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.716	2.589		1.435	0.159
	Usefulness	0.187	0.119	0.231	1.568	0.125
	Ease of Use	0.434	0.114	0.641	3.804	0.001
	Ease of Learning	-0.103	0.228	-0.068	-0.452	0.654

a. Dependent Variable: Satisfaction

Based on the above t-Test analysis, it can be concluded that the usefulness and ease of use each significantly influence satisfaction. Meanwhile, the ease of learning does not influence satisfaction. Consequently, the hypotheses can be verified as follows:

H_7: Usefulness is not statistically significant influence satisfaction.

H_8: Ease of use is statistically significant influence satisfaction.

H_9: Ease of learning is not statistically significant influence satisfaction.

4.4. Summary

There were two main objectives that should be addressed in this study. First, it needs to know whether the use of an adaptive e-learning system in the learning process could increase the student's learning outcome. This could be measured by comparing the students in the experimental group who exposed to the educational system proposed and the students in the control group who involved in the regular learning class. Several comparisons were conducted in order to explore the phenomenon that revealed. Second, it needs to evaluate whether an adaptive e-learning system could be positively used in the learning process based on the student's perspective. In order to address the research objectives, it is important to propose the research's hypotheses to interpret a certain phenomenon. As a summary, the following table provides the verification of the hypotheses proposed in this study.

Table 48. Summary of the hypotheses validation

	Hypotheses	Validation
H_1:	There is no statistically significant difference between the experimental group and control group in terms of the pre-test score of the total achievement.	Rejected
	$H_{1.1}$: There is no statistically significant difference between the experimental group and control group in terms of the pre-test score of the knowledge-level.	Rejected
	$H_{1.2}$: There is no statistically significant difference between the experimental group and control group in terms of the pre-test score of the comprehension-level.	Rejected
	$H_{1.3}$: There is no statistically significant difference between the experimental group and control group in terms of the pre-test score of the application-level.	Rejected
H_2:	There is a statistically significant difference between the experimental group and control group in terms of the post-test score of the total achievement.	Rejected
	$H_{2.1}$: There is a statistically significant difference between the experimental group and control group in terms of the post-test score of the knowledge-level.	Rejected
	$H_{2.2}$: There is a statistically significant difference between the experimental group and control group in terms of the post -test score of the comprehension-level.	Rejected
	$H_{2.3}$: There is a statistically significant difference between the experimental group and control group in terms of the post -test score of the application-level.	Rejected
H_3:	There is a statistically significant difference between the pre-test and post-test within the experimental group in terms of the mean score of the total	Supported

	achievement.	
	$H_{3.1}$: There is a statistically significant difference between the pre-test and post-test within the experimental group in terms of the mean score of the knowledge-level.	Supported
	$H_{3.2}$: There is a statistically significant difference between the pre-test and post-test within the experimental group in terms of the mean score of the comprehension-level.	Supported
	$H_{3.3}$: There is a statistically significant difference between the pre-test and post-test within the experimental group in terms of the mean score of the application-level.	Supported
H_4:	There is a statistically significant difference between the pre-test and post-test within the control group in terms of the mean score of the total achievement.	Supported
	$H_{4.1}$: There is a statistically significant difference between the pre-test and post-test within the control group in terms of the mean score of the knowledge-level.	Rejected
	$H_{4.2}$: There is a statistically significant difference between the pre-test and post-test within the control group in terms of the mean score of the comprehension-level.	Supported
	$H_{4.3}$: There is a statistically significant difference between the pre-test and post-test within the control group in terms of the mean score of the application-level.	Rejected
H_5:	There is a statistically significant difference between the experimental group and control group in terms of the gain score of the total achievement.	Supported
	$H_{5.1}$: There is a statistically significant difference between the experimental group and control group in terms of the gain score of the knowledge-level.	Supported
	$H_{5.2}$: There is a statistically significant difference between the experimental group and control group in terms of the gain score of the comprehension-level.	Supported
	$H_{5.3}$: There is a statistically significant difference between the experimental group and control group in terms of the gain score of the application-level.	Supported
H_6:	The independent variables (usefulness, ease of use, and ease of learning) all together are statistically significant influence the dependent variable (satisfaction).	Supported
H_7:	Usefulness is statistically significant influence satisfaction.	Rejected
H_8:	Ease of Use is statistically significant influence satisfaction.	Supported
H_9:	Ease of Learning is statistically significant influence satisfaction.	Rejected

5
DISCUSSION AND CONCLUSION

5.1. Introduction

This chapter discusses the findings of the study supported by the relevant literature and other similar research findings. Then, it talks about the conclusions and the possible implications of the investigation. In addition, the limitations and recommendations for potential future works are also presented.

5.2. Discussion

This section contains discussions of the results of the study. Generally, the study consists of two main areas of investigation. The first one is discussing the impact of the adaptive e-learning system used in the learning process, whether it can increase the students' knowledge achievement, especially in the Digital Simulation Course. The second is exploring the perspective of students after accessing the adaptive instructional system through usability evaluation.

5.2.1. Knowledge Achievement in the Digital Simulation Course

One of the important points in this study is regarding the comparison of cognitive achievement between the group of students who experienced the adaptive e-learning system and another group that learned in the regular setting. The adaptive e-learning system developed in this study is considering the student's learning style and initial knowledge. The main concern on this point is the students may feel comfortable with the learning environment offered by the system that suits the student's preferences. Thus, it can be initially predicted that the cognitive achievement of the students in the e-learning groups could improve significantly than those in the regular group. In terms of cognitive aspects, there are three levels considered in the achievement test based on Bloom's

taxonomy, i.e., knowledge, comprehension, and application. The reason to take into account those cognitive levels is following the characteristic of the subject itself and recommendations from some research findings (Esiobu & Soyibo, 1995; Thompson & Soyibo, 2002).

The discussion begins with the initial test results amongst both groups. It was postulated that both study groups were equal in terms of prior knowledge. Nevertheless, the findings showed that there was a significant difference between both groups in terms of initial knowledge. It is interesting to note that the regular student group had significantly higher achievement than those in the adaptive e-learning group. Although this phenomenon seems unusual, there is a rational reason for that finding.

It is important to note that the students at the Department of Computer Network Technique involved in this study divided into three groups (TKJ1, TKJ2, and TKJ3). The cluster random sampling was conducted to choose which group belongs to the experimental (utilizing adaptive e-learning) or control (regular setting) group. As a result, TKJ2 selected as a control group and TKJ3 as an experimental group. The school policy in terms of student's grouping system was placing firstly the students who had a higher entrance examination in the TKJ1. Then, it followed by putting the lower entrance score student in the TKJ2. Accordingly, the TKJ3 group was occupied by the students with the lowest grade of entrance score. From this grouping policy, it can be indicated that the students in TKJ2 group have a higher grade of competence than those in TKJ3 group. This may explain the evidence that the initial test achievement of the experimental group (TKJ3 group) had lower than that in the control group.

Another interesting finding in this study is related to the comparison of the post-test score between the experimental and control group. Since the adaptive e-learning system could suit the student's learning style, thus it can be assumed that the students in the experimental group would feel well-situated and might lead to the improvement of the post-test score. However, the result study showed an interesting finding. The mean score of each cognitive level (knowledge, comprehension, and application) of the experimental group was slightly higher than those of the control group. However, the statistical test confirmed that there was no statistically significant difference in the mean score of the student's post-test between those two groups for each cognitive level. It is interesting to note that it is difficult to see the improvement of achievement based on looking at the

post-test scores only. It will be much more realistic by analyzing the changes score resulted from the pre- and post-test scores comparison. To address this point, the next paragraphs will discuss the gain scores achieved from both groups.

Other investigations were made to measure the improvement before and after treatment both in the experimental and control group. The experimental group consisted of the students who were taught the Digital Simulation course through the adaptive e-learning system. Meanwhile, the control group was the group of students who were taught the same course in the traditional classroom setting. In order to address this comparison, a paired t-test was used to explore the changes score between the pre- and post-test score. Generally speaking, the data showed that both groups were improved in terms of the total score. In the experimental group, the total score of the post-test was significantly higher than the total score of the pre-test. The same situation is also found in the control group, although the improvement was not as high as the experimental group, it was statistically higher as well. From this finding, it can be concluded that both the e-learning and the regular groups reported the improvement in the post-test score in comparison to the pre-test score. By excluding the changes scores, it can be said that both groups have successfully provided the learning material with its particular approach to the students. Obviously, the teacher's role cannot be ignored in this study. To this respect, the characteristics of teachers may differ from one to another. Therefore, the current study attempted to manage that potential threat by assigning the same teachers for both groups.

The investigation continues by taking into detail each cognitive level. For the experimental group, it can be summarized that the mean for the post-test scores was statistically significantly higher than the mean for the pre-test scores. This finding was valid for the knowledge, comprehension, and application-level of the cognitive domain. The different situation arose in the control group. Focusing on the knowledge and application level; the results indicated that there were no statistically significant differences between the pre- and post-test. It means that there is no improvement in the post-test scores compared with the pre-test scores. Conversely, the mean score of the post-test in the comprehension level was statistically significantly higher than the pre-test. These results show that there is a statistically significant improvement from the pre- to the post-test scores regarding the comprehension level for both groups. But, the different outcomes are found in the knowledge and application levels in which the increasing scores have only significantly happened in the e-learning group.

The previous discussion talked about the comparison of pre- and post-test score between two different treatment groups. This section will more focus on the changes scores before and after the treatments. The changes score is generally known as the gain score analysis or commonly called normalized gain (N-Gain). From the N-Gain calculation, it showed that the N-Gain score for the experimental group (47.95%) was statistically significantly higher than the N-Gain score for the control group (16.02%). According to the N-Gain categorization, the improvement score of the e-learning group classified as medium gain; meanwhile, the regular group improvement was categorized as low gain. The gain score analysis was also conducted for each level of the cognitive domain. The statistical test indicated that there was a significantly higher improvement in the e-learning group compared with the regular group in terms of knowledge, comprehension, and application level. It implied from the gain score of the experimental group that significantly different than the control group. Looking at the gain categorization, for the knowledge level showed the same category, which was low gain between both groups. The same situation is found in the comprehension level, both groups showed the same category (medium gain). For the application level, the different finding revealed that the experimental group categorized as medium gain, while the control group in the low level of gain.

Further investigation was made to estimate and interpret the Effect Size (ES) to identify the power of research. Cohen's d method was used to determine the ES by calculating the mean difference between two groups and then dividing the result by the pooled standard deviation. The result showed that for the total mean score as a basis of calculation, it was interpreted as a large effect/huge effect. This evidence can be defined that the adaptive e-learning program had a positive effect on the students' achievement. With respect to the cognitive domain, the results showed that the large effect was achieved for the three lowest cognitive levels (knowledge, comprehension, and application). These findings can be interpreted that the adaptive e-learning program had a positive effect on all three lowest cognitive levels.

5.2.2. Usability Evaluation of the Adaptive E-learning System

Another main point to discuss in this study is related to the user's perspective on the usability of the adaptive e-learning system. There are many methods to excavate the usability of the system, and one widely used method is through a questionnaire. Practitioners and researchers have created many standardized questionnaires. However,

one most suitable in the context of this study and propose many advantages concerning free availability, a reasonable number of questions, and easily understandable wording items is USE Questionnaire.

USE Questionnaire is dealing with three independent variables (usefulness, ease of use, and ease of learning) and one dependent variable (satisfaction) (Lund, 2001). This questionnaire has been used in various researches domain, including training hardware equipment (Timmermans et al., 2010; Vanmulken et al., 2015), multimedia-based system (Gil et al., 2012; Noronha et al., 2012; Wallace & Yu, 2009), medical software (Barrio et al., 2016; Patwardhan et al., 2015; Peters et al., 2009; T. Wang & Dolezel, 2016; Zarabzadeh et al., 2016), mobile application (Kratz et al., 2011), and education fields (Black et al., 2008; Campos & Harrison, 2009; Faria et al., 2016; Hattink et al., 2015; Huang et al., 2013, 2012; Hung & Young, 2015; Jeong Kim et al., 2012). Regarding the criteria of validity and reliability, many studies have been proved that this psychometric tool is categorized as a valid, robust, and reliable tool to measure the usability of system or products (Chun & Katuk, 2014; Dantas et al., 2017; Gao et al., 2018; Hashim et al., 2016; Huang et al., 2013, 2012; Hung & Young, 2015; Patwardhan et al., 2015; Peters et al., 2009; Salameh, 2017; Wallace et al., 2013; Wallace & Yu, 2009).

There are a total of 42 students involved in the usability evaluation of the adaptive e-learning system. Based on the mean score of 4-point Likert scale, the finding exhibited the individual score of 3.262, 3.228, 3.360, and 3.230 for the variable of usefulness, ease of use, ease of learning, and satisfaction, respectively. Nevertheless, there is no specific way to interpret those USE score whether the score is categorized in acceptable criteria or not. However, some approaches can be used to decide the level of acceptance from those USE score.

Since the USE score constructed from the Likert scale, it can be taken into account the score justification based on the Likert scale characteristic. Babbitt and Nystrom (1989) proposed the dichotomously justification according to the direction of response. It is done by simply categorizing the rating scale as accepted or unaccepted based on the agreement or disagreement response for each item. A similar method is used by Marreez et al. (2013). This method is conducted by converting the Likert rating into “binomial data” (accept/reject). For example, when there is a 4-point Likert scale spanning from 1 (strongly

agree), 2 (agree), 3 (disagree), until 4 (strongly disagree). He then represents the score 1 and 2 as “Accept” category, and the score 3 and 4 as “Reject” category.

From both mentioned approaches, since their strategies are obviously divided the responses into two opposite categories (accept or reject), thus it can be concluded that there is a threshold in between those categories. At this point, the threshold could be a middle score of Likert scale. For instance, the 4-point Likert scale has 1+((4-1)/2) or equal to 2.5 as the threshold to divide the acceptance and rejection side. As a consequence, for the mean score resulted from the Likert scale that is same or exceeding the middle score, it is going to be in the acceptance side; otherwise, it is going to be in the rejection side. Figure 36 shows the mean score of each variable of USE Questionnaire and the threshold value.

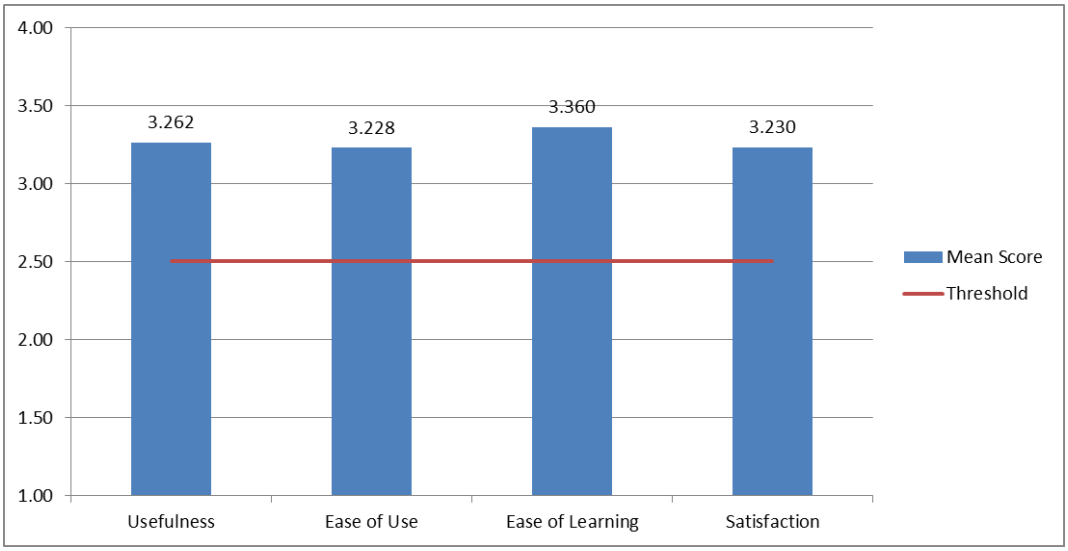


Figure 36. The mean score and threshold value

The mean score that is commonly used in statistics has the same meaning with the average score that is usually known in the general domain. At this point, the mean, or average, determines the average of a group of numbers. The mean score can be obtained by adding up several scores together and then dividing the sum by the number of scores. From the bar chart above, it can be seen that the mean score for each variable of the USE Questionnaire is exceeding the threshold value. Hence, it can be justified that the adaptive e-learning system proposed in this study is accepted by students in terms of usefulness, ease of use, ease of learning, and satisfaction.

The justification method based on the mean score used in this study has been used by many studies. Some of them are Jacucci et al. (2009), Huang et al. (2013, 2012) Chun &

Katuk (2014), Hung & Young (2015) Faria et al. (2016), and Salameh (2017). The others are visualizing the mean score into box plots (Filippidis & Tsoukalas, 2005, 2006, 2009; Filippidis & Tsoukalas, 2003; Santos, Govaerts, Verbert, & Duval, 2012), subplots (Carabalona et al., 2012), radar chart (Fu et al., 2013), or histogram (Filippidis & Tsoukalas, 2003).

Debevc & Bele (2008) conducted a different approach in order to justify the usability score. Although they used a different questionnaire, the SUMI (Kirakowski & Corbett, 1993), to evaluate the usability of system, the way they decided the acceptance of a particular system is interesting to follow. This approach starts by converting the mean score calculated from the Likert scale into a typical school score (0-100 score). The formula to convert a 4-point Likert scale used in this study into 0-100 score is as follows:

$$y_{score} = (x_{score} - x_{min}).\frac{(y_{max} - y_{min})}{(x_{max} - x_{min})}$$

where:

x_{score} = the actual Likert scale score

x_{min} = the minimum rating of Likert scale (1)

x_{max} = the maximum rating of Likert scale (4)

y_{score} = the actual 0-100 scale score

y_{min} = the minimum rating of 0-100 scale (0)

y_{max} = the maximum rating of 0-100 scale (100)

Using the conversion formula above, the individual scores of variable usefulness, ease of use, ease of learning, and satisfaction from this study are 75.407, 74.255, 78.659, and 74.332, respectively. Related to these scores, Debevc & Bele (2008) also set a positive limit of 50 to separate the acceptance and rejection area. For the score that reaches 50 and above, they can be justified as acceptable, otherwise rejected. From the scores collected from this study, it can be indicated that all variables of usefulness, ease of use, ease of learning, and satisfaction are in the acceptable criteria. It is also noteworthy that the approach used by Debevc & Bele (2008) basically produces the same result as Babbitt & Nystrom (1989) and Marrezz et al. (2013) have.

From this study's result, the usefulness score reaches 75.407 out of 100. This score is around three-quarters of the maximum score; thus it can be simply said that roughly three-quarters of the respondents (75.407%) accept the adaptive e-learning system in terms of usefulness. Other variables namely ease of use, ease of learning, and satisfaction are also in

a similar achievement, they gain 74.255, 78.659, and 74.332, respectively. These achievements might be interpreted as 74.255% of respondents agree that the system is ease of use, 78.659% of respondents feel that the system is ease of learning, and 74.332% of respondents are satisfied with the system. For a better understanding, Figure 37 shows the 0-100 score for each variable of the USE Questionnaire and the positive limit suggested by Debevc & Bele (2008).

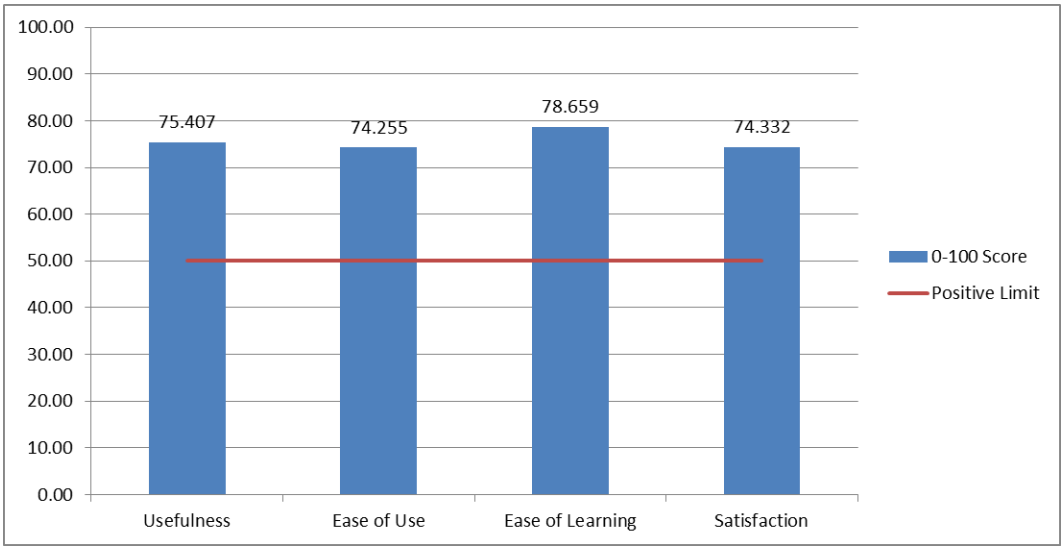


Figure 37. The 0-100 score and positive limit

The method to use the 0-100 score or the conversion to percentage to justify the USE questionnaire result has also been practiced by Filippidis & Tsoukalas (2009) and Hashim et al. (2013). According to the mean score and 0-100 score justification that has been used by many researchers in order to gauge the level of acceptance of systems or products through USE Questionnaire, it can be summarized that the adaptive e-learning system used in this experimental study has been categorized in the acceptable criteria by students in terms of usefulness, ease of use, ease of learning, and satisfaction.

As mentioned previously that the USE Questionnaire comprised of three independent variables (usefulness, ease of use, and ease of learning) and one dependent variable (satisfaction). Then, it has been discussed in the previous paragraphs about the justification approaches to measuring the acceptance level of each variable involved. From now on, it is also interesting to explore the relationship between those variables. There are two main questions that help to clarify in this respect. The first one is to what extent the independent variables (usefulness, ease of use, and ease of learning) altogether influence the dependent variable (satisfaction)? The second question is to what extent each independent variable

(usefulness, ease of use, and ease of learning) individually influence the dependent variable (satisfaction)? In order to answer those questions, the statistical techniques have been chosen and used. The first question can be answered through the F Test and the second is by t-Test.

The F Test aims to analyze whether the independent variables simultaneously influence the dependent variable. From the ANOVA table resulted from the F Test, it can be clarified that the independent variables (usefulness, ease of use, and ease of learning) altogether influence the dependent variable (satisfaction). The research from Hendra & Arifin (2018) with the title web-based usability measurement for student grading information system, although it is slightly not equal, found the same conclusion in which there was simultaneously significant influence between usefulness variable, ease to use, and ease to learn to user satisfaction variable.

Next important point needed to know is how many percentages the independent variables affect the dependent variable. In order to tackle this, the coefficient of determination is analyzed. Table 49 shows the coefficient of determination (denoted R^2 and pronounced "R-squared") from this study. The R^2 is a statistical measure to represent the proportion of the variance for a dependent variable that is explained by the independent variables. The R^2 ranges from 0 to 1 and is generally interpreted as percentages from 0% to 100%.

Table 49. The coefficient of determination

Model Summary[b]

Model	R	R Squared	Adjusted R Square	Std. Error of the Estimate
1	0.772[a]	0.596	0.564	1.369

a. Predictors: (Constant), Usefulness, Ease of Use, Ease of Learning

b. Dependent Variable: Satisfaction

The data in Table 49 exhibits that the value of R^2 reaches 0.596 and Adjusted R^2 is 0.564. Since the independent variables in this study consisted of more than 1 variable, it is necessary to consider Adjusted R^2 value as a coefficient of determination. Therefore, it can be presented that the independent variables (usefulness, ease of use, and ease of learning) simultaneously influence the dependent variable (satisfaction) around 56.4%. The remaining 43.6% (100% - 56.4%) affected by other variables that are not mentioned in this study.

In order to explore the effect of variable usefulness, ease of use, and ease of learning individually to the variable satisfaction, the t-Test was conducted. The results indicated that the variable ease of use significantly influences variable satisfaction. Meanwhile, variable usefulness and ease of learning do not significantly affect variable satisfaction. It is compared with other research findings; the current study's results concerning the variables of ease of use and ease of learning are in line with the research from Hendra & Arifin (2018). However, the finding on the variable of usefulness is contradicting with the study from Hendra & Arifin (2018).

5.3. Conclusion

The main objective of this study is coming from the common conception that one student cannot be treated as same as the others. It is also common that each student has his/her own style to know, comprehend, and absorb the information. To address this, it is crucial to provide a suitable learning environment and resources for students. The growth of technology could offer the instructional application system with the adaptivity capability. The current study is focusing on the design and development of an adaptive e-learning system by considering the student's learning styles and initial knowledge. Since the students involved in this study are coming from the engineering program, thus the widely known Felder-Silverman learning style is considered. The Felder-Silverman learning style model was constructed specifically for an engineering context (Hawk & Shah, 2007; Kapadia, 2008) and the use of its instrument for many studies was proved valid and reliable (Felder & Spurlin, 2005; Felkel & Gosky, 2012; Litzinger et al., 2005, 2007; Livesay et al., 2002; Platsidou & Metallidou, 2009; Van Zwanenberg et al., 2000; Zywno, 2003). This study also takes into consideration the three lowest levels of cognitive Bloom's domain to assess the initial and post-treatment achievement. These selected cognitive levels are resulted from the reviewing of the established syllabi from the intended subject and also in line with other studies (Esiobu & Soyibo, 1995; Thompson & Soyibo, 2002).

The results of the empirical analysis found a number of interesting issues. By comparing the group of students mediated with the adaptive e-learning program with another group of students in the regular classroom setting, the improvement of achievement score of the e-learning group is exceeding the traditional one. It is important to bring in mind that traditional instruction may be conveyed in a general way. It might happen that one student is difficult to absorb the information that is explained with the un-preferred way.

Meanwhile, the adaptive e-learning program is offering a suitable method for each different personality of students. Since the e-learning group in this study has experimented in a blended learning approach, thus it is still possible for the students to actively interact with the teacher as it is generally happened in the traditional one. From this point, it can be noted that the students in the e-learning group could get the learning benefits both from face-to-face learning strategy and through the adaptive learning environment. The blended learning is chosen because the regulation in the targeted school mentioned that the learning process should be supervised by the teacher. The students could not merely utilize the adaptive e-learning system by themselves without any guidance from the teacher. The adaptive e-learning system is basically a medium to help the teacher to provide the learning material more structured and adaptable to the student's preferences. The presence of the teacher may support a discussion activity, a question-and-answer session, and guiding the whole learning process.

The results of this study indicated that although the initial knowledge of students in the e-learning group is significantly lower than those in the regular group, the gain score in the treatment group is significantly higher in comparison with its counterpart. This means that the learning process by utilizing the adaptive e-learning system in the experimental group is more effective than the control group which delivered through the traditional setting. This positive result is revealed because the adaptive e-learning may provide a suitable learning environment and material to each individual student. The ability of the e-learning system to provide different presentation and navigation in four dimensions of learning style is the most important part of this study. The personalization of learning material and navigation that suit the student's preferences may grant the comfort and ease to learn. As a consequence, it may increase the learning outcomes as reported in this current study.

Taking into detail each level in the cognitive domain, it is also found that there is a significantly higher improvement in the post-test score compared with the pre-test score in terms of the experimental group. This finding is applicable to the level of knowledge, comprehension, and application of the cognitive domain. It is essential to remember that the knowledge level deals with the basic level of cognitive domain such as recalling or remembering previously learned information. The comprehension level involves understanding and interpreting incoming information. Meanwhile, the application level concerns the ability to use prior gathered information to solve the problem. Concerning

those cognitive levels, the adaptive e-learning proposed in this study is able to provide the learning resources dealing with knowledge, comprehension, and application levels.

Another main objective of this study focuses on the usability evaluation. After collecting and analyzing some widely-known usability questionnaires, this study considers using USE questionnaire to gather the students' opinions on the usability of the adaptive e-learning program. According to the usability score analysis by considering some usability justification approaches, the finding shows that the total usability score collected are categorized in acceptable criteria. It means that the adaptive e-learning system proposed in this study is useful for learning. The findings also show that the usability scores for each variable (usefulness, ease of use, ease of learning, and satisfaction) are classified in the acceptable range. These lead to the conclusion that the majority of students agree that the personalized e-learning application in this study is useful, easy to use, easy to learn, and satisfying.

Furthermore, a multiple linear regression analysis was conducted to observe the relationship amongst variables involved in the usability questionnaire. The regression analysis clarified that the independent variables (usefulness, ease of use, and ease of learning) altogether significantly affect the dependent variable (satisfaction). However, the partial regression test reported varied findings. The first result indicated that there is a significant effect of ease of use aspect to the satisfaction. However, other aspects (usefulness and ease of learning) are not significantly influenced satisfaction. These findings lead to the conclusion that although there is a simultaneously significant positive effect of the independent variables to the dependent variable, the majority contribution is made by variable ease of use. The others (usefulness and ease of learning) are not significantly contributed.

The positive results of this study cannot be separated from other positive contributions. One of the most important parts to contribute to the e-learning practice is the computer and network infrastructure. This is also a strategic issue that will be a high priority for MoEC to implement ICT in the education sector (Kadir et al., 2016; Kementerian Pendidikan dan Kebudayaan, 2010). The targeted school in this study has a good computer laboratory supported with a high-performance computer and high-speed intranet network. This environment may allow the adaptive e-learning application in this study could run perfectly.

For other schools that are still lacking on the computer and network infrastructure should consider other ways to implement this computer-based educational system.

The positive results of this study may implicate to the extension of the adaptive e-learning for other engineering subjects. Although the results may be different, by following the procedures mentioned in this study may find a positive result. This can be utilized by the vocational education schools in providing a good computer-based educational application in order to support the high-number vocational schools as an effect of the strategic plan from MoEC (Departemen Pendidikan Nasional, 2005) to increase the ratio of vocational compared with the general schools.

5.4. Limitation and Recommendation

Although the results of this study seem promising, these results are only eligible for the specific participants, subject's course, and experimental treatment. In terms of the number of participants, there were 42 students in total who participated in this experimental study. Those students came only from one public technical high school in one region in Indonesia. As the characteristics of students may differ from one school to another school and from one region to another region; thus, the findings of this study cannot be generalized to the other specific populations. It leads to the recommendation to do another experiment with a broader sample. The higher the number of the sample involved in one investigation, the result may bring to the generalizable conclusion. However, on the other hand, the higher number of the sample may take more complexity in the implementation and need more resources support.

Concerning the subject's course implemented in this experimental study, the material content was related to the Digital Simulation course. The Digital Simulation course is one of the mandatory courses in the first grade of Computer Network Techniques department. Although the adaptive e-learning system in this study was constructed as a Learning Management System (LMS) in which it is possible to change the material content to suit other courses. However, the one installed for this study purpose is prepared for the Digital Simulation course. Therefore, the result of this study is only representing the specific subject's course. The use of this adaptive e-learning system contained other subject's courses may corroborate the findings of this study.

It is also noteworthy to understand that the adaptive e-learning system designed in this study was constructed to accommodate the cognitive domain only. According to the widely known Bloom's taxonomy, this cognitive domain classified into six hierarchical levels from knowledge as the lowest level to evaluation as the top level. This current study, based on the learning objective of the Digital Simulation course, was considered the three lowest levels of Bloom (knowledge, comprehension, and application) for constructing the initial test. For future research, it would be interesting to consider beyond the application level. There are other important domains, namely affective and psychomotor domains. In order to address those domains in the initial test construction, it needs some additional specific analysis and design. However, it is becoming a promising idea for further research to prepare the adaptive e-learning system that has an ability to handle the affective and/or psychomotor aspect(s).

5.5. Summary

The main aim of this study was first to investigate the achievement of the students who utilized an adaptive e-learning application compared with the students who followed the regular classroom setting. After considering certain aspects of participants' involvement and some other constraints such as meeting schedule and infrastructure support, the Digital Simulation course was selected and designed as a subject course in this experimental study. The development of the adaptive e-learning system was considering the student's learning style based on one widely known Felder-Silverman model. Another adaptation variable used in the e-learning is the student's initial knowledge in which assessed according to the three lowest levels of Bloom's cognitive domain (knowledge, comprehension, and application). The second aim was to explore the usability evaluation of the adaptive e-learning system based on the student's perspective through USE questionnaire. Furthermore, it was also analyzed the relationship between the variables involved in the usability questionnaire used.

The use of e-learning system that capable to suit the student's preferences was expected to enhance the learning outcome and to lead the satisfaction to use the instructional system. In order to address justify those expectations, a number of statistical techniques were used to calculate and evaluate the collected data. The basic descriptive statistics such as mean and standard deviation were employed in order to provide the brief information of the study's data. Then the independent and paired t-tests were conducted to compare

between two groups of data. Generally speaking, the adaptive e-learning system looked promising by performing well in terms of functionality and providing a personalized learning environment. The achievement of the students in the e-learning group was exceeding significantly than those in the regular group. Furthermore, in order to explore the relationship amongst variables used in the usability evaluation, the multiple linear regression analysis was performed. It can be summarized that the students felt satisfied with the personalized instructional application. However, some recommendations in terms of participants' number, course characteristics, and the consideration of other domains (affective and psychomotor) are necessary for further investigation.

REFERENCES

Albertazzi, D., Okimoto, M. L., & Ferreira, M. G. G. (2012). Developing an usability test to evaluate the use of augmented reality to improve the first interaction with a product. *Work*, *41*(Supplement 1), 1160–1163.

Alfonseca, E., Carro, R. M., Martin, E., Ortigosa, A., & Paredes, P. (2006). The impact of learning styles on student grouping for collaborative learning: a case study. *User Modeling and User-Adapted Interaction*, *16*(3–4), 377–401.

Allen, W. C. (2006). Overview and evolution of the ADDIE training system. *Advances in Developing Human Resources*, *8*(4), 430–441.

Allinson, C. W., & Hayes, J. (1988). The learning styles questionnaire: an alternative to Kolb's inventory? *Journal of Management Studies*, *25*(3), 269–281.

Allwood, C. M. (1984). Error detection processes in statistical problem solving. *Cognitive Science*, *8*(4), 413–437.

American Educational Research Association. (1999). *Standards for educational and psychological testing*. American Educational Research Association.

American Psychological Association. (2002). Ethical principles of psychologists and code of conduct. *American Psychologist*, *57*(12), 1060–1073.

Anastasi, A., & Urbina, S. (1997). *Psychological testing*. Prentice Hall/Pearson Education.

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman.

APJII. (2017). Penetrasi & Perilaku Pengguna Internet Indonesia. *Infografis Hasil Survey*, 1–35.

Ary, D., Jacobs, L. C., Irvine, C. K. S., & Walker, D. (2018). *Introduction to research in education*. Cengage Learning.

Asian Development Bank. (2009). *Good Practice in Technical and Vocational Education and Training*. Mandaluyong City, Philippines: Asian Development Bank.

Assila, A., Oliveira, K. M., & Ezzedine, H. (2016). Standardized usability questionnaires: Features and quality focus. *Electronic Journal of Computer Science and Information*

Technology: EJCIST, *6*(1).

Babbitt, B. A., & Nystrom, C. O. (1989). Questionnaire Construction Manual. https://doi.org/10.21236/ada212365

Badan Pusat Statistik. (2010). *Sensus Penduduk Indonesia 2010*. *Jakarta: Badan Pusat Statistik*.

Badan Pusat Statistik. (2013). *Proyeksi Penduduk Indonesia 2010-2035*. Jakarta: Badan Pusat Statistik.

Baker, T. L. (1988). *Doing social research*. McGraw-Hill College.

Bao, L. (2006). Theoretical comparisons of average normalized gain calculations. *American Journal of Physics*, *74*(10), 917–922.

Bappeda DIY. (2015a). Jumlah Lulusan yang Melanjutkan ke Jenjang SMP, SMA, SMK. Retrieved from http://bappeda.jogjaprov.go.id/dataku/data_profil/index/533/0/2

Bappeda DIY. (2015b). Jumlah Sekolah. Retrieved from http://bappeda.jogjaprov.go.id/dataku/data_profil/index/478/0/2

Barrio, P., Ortega, L., Bona, X., & Gual, A. (2016). Development, validation, and implementation of an innovative mobile app for alcohol dependence management: protocol for the SIDEAL trial. *JMIR Research Protocols*, *5*(1), e27.

Bean, M. (2015). *Laravel 5 essentials*. Packt Publishing Ltd.

Bell, J. (2005). Doing your research project: A guide for first-time researchers in education, health and social science. Open University Press.

Bell, J. (2010). Doing Your Research Project: A guide for first-time researchers in education, health and social science 5th edition. New-York: McGraw-Hill International.

Bell, J. (2014). *Doing Your Research Project: A guide for first-time researchers*. McGraw-Hill Education (UK).

Black, E. W., Ferdig, R. E., & DiPietro, M. (2008). An overview of evaluative instrumentation for virtual high schools. *The Amer. Jrnl. of Distance Education*, *22*(1), 24–45.

Black, T. R. (2002). *Understanding social science research*. Sage.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Karthwohl, D. R. (1956). Taxonomy of educational objectives Handbook I: Cognitive domain. *New York: McKay*, 20–24.

Blum, M. L., & Foos, P. W. (1986). *Data gathering: Experimental methods plus*. HarperCollins Publishers.

Bolisani, E., & Bratianu, C. (2018). The elusive definition of knowledge. In *Emergent Knowledge Strategies* (pp. 1–22). Springer.

Boyle, C., & Encarnacion, A. O. (1998). MetaDoc: an adaptive hypertext reading system. In *Adaptive Hypertext and Hypermedia* (pp. 71–89). Springer.

Bra, P. De, & Calvi, L. (1998). AHA! An open adaptive hypermedia architecture. *New Review of Hypermedia and Multimedia*, *4*(1), 115–139.

Branson, R. K. (1978). The interservice procedures for instructional systems development. *Educational Technology*, *18*(3), 11–14.

Brooke, J. (1996). SUS - A quick and dirty usability scale. *Usability Evaluation in Industry*, *189*(194), 4–7. https://doi.org/10.1002/hbm.20701

Brown, E., Brailsford, T., Fisher, T., Moore, A., & Ashman, H. (2006). Reappraising cognitive styles in adaptive web applications. In *Proceedings of the 15th international conference on World Wide Web* (pp. 327–335).

Brusilovski, P., Kobsa, A., & Nejdl, W. (2007). *The adaptive web: methods and strategies of web personalization* (Vol. 4321). Springer Science & Business Media.

Brusilovsky, P. (1996). Methods and techniques of adaptive hypermedia. *User Modeling and User-Adapted Interaction*, *6*(2), 87–129.

Brusilovsky, P. (2000). Adaptive hypermedia: From intelligent tutoring systems to Web-based education. In *International Conference on Intelligent Tutoring Systems* (pp. 1–7).

Brusilovsky, P. (2001a). Adaptive educational hypermedia. In *International PEG Conference* (Vol. 10, pp. 8–12).

Brusilovsky, P. (2001b). Adaptive Hypermedia. *User Modeling and User-Adapted Interaction, Ten Year Anniversary Issue 11 (Alfred Kobsa, Ed.)*, 87–110.

Brusilovsky, P. (2004). Adaptive navigation support: From adaptive hypermedia to the adaptive web and beyond. *PsychNology Journal*, *2*(1), 7–23.

Brusilovsky, P. (2007). Adaptive navigation support. *The Adaptive Web*, 263–290.

Brusilovsky, P., & Eklund, J. (1998). A study of user model based link annotation in

educational hypermedia. *Journal of Universal Computer Science*, *4*(4), 429–448.

Brusilovsky, P., Eklund, J., & Schwarz, E. (1998). Web-based education for all: a tool for development adaptive courseware. *Computer Networks and ISDN Systems*, *30*(1–7), 291–300.

Brusilovsky, P. L. (1992). A framework for intelligent knowledge sequencing and task sequencing. In *International Conference on Intelligent Tutoring Systems* (pp. 499–506).

Brusilovsky, P., & others. (1999). Adaptive and intelligent technologies for web-based eduction. *Ki*, *13*(4), 19–25.

Brusilovsky, P., & Peylo, C. (2003). Adaptive and intelligent web-based educational systems. *International Journal of Artificial Intelligence in Education (IJAIED)*, *13*, 159–172.

Brusilovsky, P., Schwarz, E., & Weber, G. (1996). ELM-ART: An intelligent tutoring system on World Wide Web. In *International conference on intelligent tutoring systems* (pp. 261–269).

Calvi, L. (1998). *A Proficiency-Adapted Framework for Browsing and Information Filtering in Web-Based Educational Systems. Methodological Implications for Language Learning on the WWW*. Universitaire Instelling Antwerpen.

Campos, J. C., & Harrison, M. D. (2009). Interaction engineering using the IVY tool. In *Proceedings of the 1st ACM SIGCHI symposium on Engineering interactive computing systems* (pp. 35–44).

Carabalona, R., Grossi, F., Tessadri, A., Castiglioni, P., Caracciolo, A., & de Munari, I. (2012). Light on! Real world evaluation of a P300-based brain--computer interface (BCI) for environment control in a smart home. *Ergonomics*, *55*(5), 552–563.

Carmona, C., Castillo, G., & Millán, E. (2007). Discovering student preferences in e-learning. In *Proceedings of the international workshop on applying data mining in e-learning* (pp. 33–42).

Carver, C. A., Howard, R. A., & Lane, W. D. (1999). Enhancing student learning through hypermedia courseware and incorporation of student learning styles. *IEEE Transactions on Education*, *42*(1), 33–38.

Chapin, N. (2003). *Flowchart*. John Wiley and Sons Ltd.

Chen, S., & Zhang, J. (2008). The Adaptive Learning System based on Learning Style and

Cognitive State. *Proceedings - 2008 International Symposium on Knowledge Acquisition and Modeling, KAM 2008*, 302–306. https://doi.org/10.1109/KAM.2008.60

Chin, J. P., Diehl, V. A., & Norman, K. L. (1988). Development of an instrument measuring user satisfaction of the human-computer interface. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 213–218).

Chun, K. L., & Katuk, N. (2014). A usability study of social media credentials as a single-sign-on mechanism: Student access to online teaching materials. *Journal of Industrial and Intelligent Information*, *2*(3).

Clark, R. (2002). Six principles of effective e-Learning: What works and why. *The E-Learning Developer's Journal*, *6*(2), 1–10.

Clark, R. C., & Mayer, R. E. (2016). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*. John Wiley & Sons.

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Routledge.

Cohen, L., Manion, L., & Morrison, K. (2002). *Research methods in education*. Routledge.

Conrad, D. (2006). E-Learning and social change: An apparent contradiction. *Perspectives on Higher Education in the Digital Age*, 21–33.

Creswell, J. W. (2002). *Educational research: Planning, conducting, and evaluating quantitative*. Prentice Hall Upper Saddle River, NJ.

Cristea, A. I., & De Mooij, A. (2003). Adaptive course authoring: My online teacher. In *10th International Conference on Telecommunications, 2003. ICT 2003.* (Vol. 2, pp. 1762–1769).

Crocker, L., & Algina, J. (1986). *Introduction to classical and modern test theory.* ERIC.

Dantas, C., Jegundo, A. L., Quintas, J., Martins, A. I., Queirós, A., & Rocha, N. P. (2017). European portuguese validation of usefulness, satisfaction and ease of use questionnaire (USE). In *World Conference on Information Systems and Technologies* (pp. 561–570).

De Bra, P., Aerts, A., Berden, B., De Lange, B., Rousseau, B., Santic, T., … Stash, N. (2003). AHA! The adaptive hypermedia architecture. In *Proceedings of the fourteenth ACM conference on Hypertext and hypermedia* (pp. 81–84).

De Bra, P., Aroyo, L., & Cristea, A. (2004). Adaptive web-based educational hypermedia. In *Web Dynamics* (pp. 387–410). Springer.

De Bra, P., Brusilovsky, P., & Houben, G.-J. (1999). Adaptive hypermedia: from systems to framework. *ACM Computing Surveys (CSUR)*, *31*(4es), 12.

De Bra, P., & Calvi, L. (1997). Creating Adaptive Hyperdocuments for and on the Web. In *WebNet*.

De Bra, P., Houben, G.-J., & Wu, H. (1999). AHAM: a Dexter-based reference model for adaptive hypermedia. In *Proceedings of the tenth ACM Conference on Hypertext and hypermedia: returning to our diverse roots: returning to our diverse roots* (pp. 147–156).

Debevc, M., & Bele, J. L. (2008). Usability testing of E-Learning content as used in two learning management systems. *European Journal of Open, Distance and E-Learning*, 1–8. Retrieved from http://www.eurodl.org/?article=296.

Departemen Pendidikan Nasional. (2005). RENSTRA Departemen Pendidikan Nasional 2005-2009. *Jakarta: Departemen Pendidikan Nasional*.

Depdiknas. (2003). UU No. 20 Tahun 2003 tentang Sistem Pendidikan Nasional. Jakarta: Depdiknas.

Depdiknas. (2012). UU No. 12 Tahun 2012 tentang Pendidikan Tinggi. Jakarta: Depdiknas.

Dick, W., Carey, L., & Carey, J. O. (2005). The systematic design of instruction.

Dikdasmen. (2016). Spektrum Keahlian Pendidikan Menengah Kejuruan. Jakarta: Dikdasmen.

Direktorat Pembinaan SMA Kemdiknas. (2010). Panduan Pengembangan Bahan Ajar Berbasis TIK. *Jakarta: Direktorat Pembinaan Sekolah Menengah Atas*.

Dix, A., Finlay, J. E., Abowd, G. D., & Beale, R. (2004). *Human-Computer Interaction* (3rd ed.). England: Pearson Education Limited.

Dringus, L. P., & Cohen, M. S. (2005). An adaptable usability heuristic checklist for online courses. In *Proceedings Frontiers in Education 35th Annual Conference* (p. T2H--6).

Dung, P. Q., & Florea, A. M. (2013). Adaptation To Learners' Learning Styles In A Multi-Agent E-Learning System. *Internet Learning*, *2*(1), 4.

Dunn, R. (1990). Understanding the Dunn and Dunn learning styles model and the need for individual diagnosis and prescription. *Reading, Writing, and Learning Disabilities*, *6*(3), 223–247. https://doi.org/10.1080/0748763900060303

Dunn, R., Griggs, S. A., Olson, J., Beasley, M., & Gorman, B. S. (1995). A meta-analytic validation of the Dunn and Dunn model of learning-style preferences. *The Journal of Educational Research*, *88*(6), 353–362.

Dunn, R. S., & Dunn, K. J. (1989). *Learning style inventory*. Price Systems New York, Lawrence, KS.

Eklund, J., & Sinclair, K. (2000). An empirical appraisal of the effectiveness of adaptive interfaces for instructional systems. *Journal of Educational Technology & Society*, *3*(4), 165–177.

Esiobu, G. O., & Soyibo, K. (1995). Effects of concept and vee mappings under three learning modes on students' cognitive achievement in ecology and genetics. *Journal of Research in Science Teaching*, *32*(9), 971–995.

Essaid El Bachari, E. H. A., & El Adnani, M. (2011). E-LEARNING PERSONALIZATION BASED ON DYNAMIC LEARNERS' PREFERENCE.

Faria, T. V. M., Pavanelli, M., & Bernardes, J. L. (2016). Evaluating the Usability Using USE Questionnaire: Mindboard System Use Case. In *International Conference on Learning and Collaboration Technologies* (pp. 518–527).

Felder, R. M. (1996). Matters of Style. *ASEE Prism*, *6*(4), 18–23. https://doi.org/10.1021/ie50125a002

Felder, R. M., & Brent, R. (2005). Understanding student differences. *Journal of Engineering Education*, *94*(1), 57–72.

Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering Education*, *78*(7), 674–681.

Felder, R. M., & Spurlin, J. (2005). Applications, reliability and validity of the Index of Learning Styles. *International Journal of Engineering Education*, *21*(1), 103–112.

Felkel, B. H., & Gosky, R. M. (2012). A Study of Reliability and Validity of the Felder-Soloman Index of Learning Styles for Business Students. In *Proceedings of the Annual International Conference on Technology in Collegiate Mathematics*.

Filippidis, S. K., & Tsoukalas, I. A. (2005). Adaptable instructional video: Using instructional video with adaptable content to teach a computer science course. In *Proceedings of the IADIS International Conference on COGNITION AND EXPLORATORY LEARNING IN DIGITAL AGE (CELDA 2005): Porto, Portugal, December 14-16, 2005* (pp. 269–276).

Filippidis, S. K., & Tsoukalas, I. A. (2006). Teaching a computer science course using adaptable instructional images. In *IFIP International Conference on Artificial Intelligence Applications and Innovations* (pp. 401–408).

Filippidis, S. K., & Tsoukalas, I. A. (2009). On the use of adaptive instructional images based on the sequential--global dimension of the Felder--Silverman learning style theory. *Interactive Learning Environments*, *17*(2), 135–150.

Filippidis, S., & Tsoukalas, I. (2003). Using digital video as an asynchronous method of instruction. In *Proceedings 3rd IEEE International Conference on Advanced Technologies* (pp. 130–134).

Fleming, N., & Baume, D. (2006). Learning Styles Again: VARKing up the right tree! *Educational Developments*, *7*(4), 4.

Fleming, N. D. (2001). *Teaching and learning styles: VARK strategies*. IGI global.

Fleming, N. D. (2006). VARK visual, aural/auditory, read/write, kinesthetic. *New Zealand: Bonwell Green Mountain Falls*.

Forehand, M., & others. (2005). Bloom's taxonomy: Original and revised. *Emerging Perspectives on Learning, Teaching, and Technology*, *8*.

Franzoni, A. L., Assar, S., Defude, B., & Rojas, J. (2008). Student learning styles adaptation method based on teaching strategies and electronic media. In *Advanced Learning Technologies, 2008. ICALT'08. Eighth IEEE International Conference on* (pp. 778–782). IEEE.

Fu, B., Noy, N. F., & Storey, M.-A. (2013). Indented tree or graph? A usability study of ontology visualization techniques in the context of class mapping evaluation. In *International Semantic Web Conference* (pp. 117–134).

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). *Educational research: An introduction*. Longman Publishing.

Gao, M., Kortum, P., & Oswald, F. (2018). Psychometric evaluation of the USE (Usefulness,

Satisfaction, and Ease of use) questionnaire for reliability and validity. In *Proceedings of the human factors and ergonomics society annual meeting* (Vol. 62, pp. 1414–1418).

Gil, N., Silva, N., Duarte, E., Martins, P., Langlois, T., & Chambel, T. (2012). Going through the clouds: search overviews and browsing of movies. In *Proceeding of the 16th International Academic MindTrek Conference* (pp. 158–165).

Gonschorek, M., & Herzog, C. (1995). Using hypertext for an adaptive helpsystem in an intelligent tutoring system. In *Proceedings of AI-ED* (Vol. 95, pp. 274–281).

Graf, S., Viola, S. R., Leo, T., & Kinshuk. (2007). In-depth analysis of the Felder-Silverman learning style dimensions. *Journal of Research on Technology in Education*, *40*(1), 79–93.

Guspatni, M. (2018). Students activities in, perceptions of and expectations for e-learning: A case in Indonesia. *Knowledge Management & E-Learning: An International Journal*, *10*(1), 97–112.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., Tatham, R. L., & others. (2009). Multivariate data analysis (7th. ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

Hake, R. R. (1999). Analyzing change/gain scores. *Unpublished.[Online] URL: Http://Www. Physics. Indiana. Edu/~ Sdi/AnalyzingChange-Gain. Pdf*.

Halasz, F., & Schwartz, M. (1994). The Dexter Hypertext Reference Model. *Communications of the ACM 37, 2*, 30–39.

Hariyanto, D., & Köhler, T. (2016). A Proposed Architectural Model for an Adaptive E-Learning System Based on Student's Learning Styles and Knowledge Level. In *International Conference on Teaching and Learning in Education* (pp. 18–22).

Hariyanto, D., & Köhler, T. (2017a). An Adaptive User Interface for an E-learning System by Accommodating Learning Style and Initial Knowledge. *Proceedings of the International Conference on Technology and Vocational Teachers (ICTVT 2017)*. https://doi.org/10.2991/ictvt-17.2017.4

Hariyanto, D., & Köhler, T. (2017b). Measuring knowledge in computer network vocational training by monitoring learning style preferences of students. In *Wissensgemeinschaften in Wirtschaft, Wissenschaft und Offentlicher Verwaltung - 20. Workshop GeNeMe 2017, Gemeinschaften in Neuen Medien* (Vol. 2017–Octob, pp.

183–195).

Hashim, A. F. M., Hussin, H., Othman, M. H., & Ahmad, S. A. S. (2016). Usability Evaluation of a Desktop Virtual Reality Prototype (DVRP) courseware to enhance knowledge on drug abuse. *Journal of Techno Social*, *8*(1).

Hashim, W. N. W., Othman, M. R., Syafiq, M. I., & others. (2013). Evaluation of end-user satisfaction among employees participating in a web-based needs assessment inventory. *Procedia-Social and Behavioral Sciences*, *97*, 766–770.

Hattink, B., Meiland, F., van der Roest, H., Kevern, P., Abiuso, F., Bengtsson, J., … others. (2015). Web-based STAR E-learning course increases empathy and understanding in dementia caregivers: results from a randomized controlled trial in the Netherlands and the United Kingdom. *Journal of Medical Internet Research*, *17*(10), e241.

Hauger, D., & Köck, M. (2007). State of the Art of Adaptivity in E-Learning Platforms. In *LWA* (pp. 355–360).

Hawk, T. F., & Shah, A. J. (2007). Using learning style instruments to enhance student learning. *Decision Sciences Journal of Innovative Education*, *5*(1), 1–19.

Haynes, S. N., Richard, D., & Kubany, E. S. (1995). Content validity in psychological assessment: a functional approach to concepts and methods. *Psychological Assessment*, *7*(3), 238.

Hendra, & Arifin, Y. (2018). Web-based Usability Measurement for Student Grading Information System. *Procedia Computer Science*, *135*, 238–247.

Hertzog, M. A. (2008). Considerations in determining sample size for pilot studies. *Research in Nursing & Health*, *31*(2), 180–191.

Hinton, P. R., McMurray, I., & Brownlow, C. (2004). *SPSS explained*. Routledge.

Ho, R. (2006). *Handbook of univariate and multivariate data analysis and interpretation with SPSS*. Chapman and Hall/CRC.

Holzinger, A. (2005). Usability engineering methods for software developers. *Communications of the ACM*, *48*(1), 71–74. https://doi.org/10.1145/1039539.1039541

Honey, P., & Mumford, A. (1982). The Manual of Learning Styles. *Maidenhead: Peter Honey*.

Honey, P., & Mumford, A. (1992). The manual of learning styles, 3rd. *Maidenhead: Peter*

Honey.

Honey, P., & Mumford, A. (2000). *The learning styles helper's guide*. Peter Honey Publications Maidenhead.

Hong, H., & Kinshuk. (2004). Adaptation to student learning styles in web based educational systems. In *EdMedia+ Innovate Learning* (pp. 491–496).

Huang, Y.-M., Liang, T.-H., & Chiu, C.-H. (2013). Gender differences in the reading of e-books: Investigating children's attitudes, reading behaviors and outcomes. *Journal of Educational Technology & Society*, *16*(4), 97–110.

Huang, Y.-M., Liang, T.-H., Su, Y.-N., & Chen, N.-S. (2012). Empowering personalized learning with an interactive e-book learning system for elementary school students. *Educational Technology Research and Development*, *60*(4), 703–722.

Hung, H.-C., & Young, S. S.-C. (2015). The Effectiveness of Adopting E-Readers to Facilitate EFL Students' Process-Based Academic Writing. *Educational Technology & Society*, *18*(1), 250–263.

Hunt, D. P. (2003). The concept of knowledge and how to measure it. *Journal of Intellectual Capital*, *4*(1), 100–113.

IEEE. (1990). IEEE standard glossary of software engineering terminology. *IEEE Std*, *610121990*(121990), 3.

Imbimbo, J., & Gilkes, A. (2009). Block Scheduling: Center for School Success Promising Practices Series. *New Visions for Public Schools*.

Indonesia. (2017). Identification of Islands and Standardization of Their Names.

ISO. (1998). ISO 9241-11: Guidance on Usability. *International Organization for Standardization*, *1998*(2), 28. https://doi.org/10.1038/sj.mp.4001776

ISO. (2000). ISO/IEC FDIS 9126-1: Software engineering--Product quality--Part 1: Quality model.

Ivers, K. S., & Barron, A. E. (1998). *Multimedia projects in education: Designing, producing, and assessing*. Libraries Unlimited Englewood, CO.

Izurieta, C., & Bieman, J. M. (2007). How software designs decay: A pilot study of pattern evolution. In *null* (pp. 449–451).

Jacucci, G., Spagnolli, A., Gamberini, L., Chalambalakis, A., Björksog, C., Bertoncini, M., … Monti, P. (2009). Designing Effective Feedback of Electricity Consumption for Mobile User Interfaces. *PsychNology Journal*, *7*(3).

Jeong Kim, H., Pederson, S., & Baldwin, M. (2012). Improving user satisfaction via a case-enhanced e-learning environment. *Education+ Training*, *54*(2/3), 204–218.

Jevremović, M., & Vasić, Z. (2010). Adaptive e-learning. *Acta Facultatis Medicae Naissensis*, *27*(4).

Jogiyanto, H. M. (2005). Analisis dan desain sistem informasi. *Yogyakarta: Andi Offset*.

Kadir, S., Nirwansyah, & Ayasha Bachrul, B. (2016). Technical and Vocational Education and Training in Indonesia: Challenges and Opportunities for the Future.

Kahnwald, N., & Köhler, T. (2009). Usability evaluation within the rural wings project - a multi-method approach. In *Proceedings of the international rural wings closing conference*. Athens, University Press.

Kapadia, R. J. (2008). Teaching and learning styles in engineering education. In *Frontiers in Education Conference, 2008. FIE 2008. 38th Annual* (p. T4B–1–T4B–4). IEEE.

Kareal, F., & Klema, J. (2006). Adaptivity in e-learning. *Current Developments in Technology-Assisted Education*, *1*, 260–264.

Kementerian Pendidikan dan Kebudayaan. (2010). *Rencana Strategis Kementerian Pendidikan dan Kebudayaan 2010-2014*. Jakarta: Kementerian Pendidikan dan Kebudayaan.

Kerlinger, F. N., & Lee, H. B. (1999). Foundations of Behavioral Research.

Khan, B. H. (2001). *Web-based training*. Educational Technology.

Kieser, M., & Wassmer, G. (1996). On the use of the upper confidence limit for the variance from a pilot sample for sample size determination. *Biometrical Journal*, *38*(8), 941–949.

Kirakowski, J., & Corbett, M. (1993). SUMI: The software usability measurement inventory. *British Journal of Educational Technology*, *24*(3), 210–212.

Kiselev, A., & Loutfi, A. (2012). Using a mental workload index as a measure of usability of a user interface for social robotic telepresence. In *2nd Workshop of Social Robotic Telepresence in Conjunction with IEEE International Symposium on Robot and Human*

Interactive Communication 2012.

Kitchener, K. S., & Anderson, S. K. (2011). *Foundations of ethical practice, research, and teaching in psychology and counseling*. Routledge.

Klašnja-Milićević, A., Vesin, B., Ivanović, M., & Budimac, Z. (2011). E-Learning personalization based on hybrid recommendation strategy and learning style identification. *Computers & Education*, *56*(3), 885–899.

Kolb, D. A. (1976). *Learning style inventory technical manual*. McBer Boston, MA.

Kolb, D. A. (2011). *The Kolb learning style inventory 4.0*. Hay Resources Direct Boston, MA.

Kothari, C. R. (2009). *Research methodology: Methods and techniques*. New Age International.

Krathwohl, D. R., Bloom, B. S., & Masia, B. B. (1964). Taxonomy of educational objectives Handbook II: Affective domain. *Affective Domain. New York: David McKay*.

Kratz, S., Westermann, T., Rohs, M., & Essl, G. (2011). CapWidgets: tangile widgets versus multi-touch controls on mobile devices. In *CHI'11 Extended Abstracts on Human Factors in Computing Systems* (pp. 1351–1356).

Kuljis, J., & Liu, F. (2005). A Comparison of Learning Style Theories on the Suitability for elearning. *Web Technologies, Applications, and Services*, *2005*, 191–197.

Lackey, N. R., & Wingate, A. L. (1997). The Pilot Study: One Key. *Advanced Design in Nursing Research*, 375.

Landauer, T. K. (1997). Behavioral research methods in human-computer interaction. In *Handbook of Human-Computer Interaction (Second Edition)* (pp. 203–227). Elsevier. https://doi.org/10.1016/b978-044481862-1/50075-3

Latham, A., Crockett, K., McLean, D., & Edmonds, B. (2012). A conversational intelligent tutoring system to automatically predict learning styles. *Computers & Education*, *59*(1), 95–109.

Lazarinis, F., Green, S., & Pearson, E. (2010). Creating personalized assessments based on learner knowledge and objectives in a hypermedia Web testing application. *Computers & Education*, *55*(4), 1732–1743.

Leavy, P. (2017). *Research design: Quantitative, qualitative, mixed methods, arts-based, and*

community-based participatory research approaches. Guilford Publications.

Lee, C. K., & Sidhu, M. S. (2015). Engineering students learning preferences in UNITEN: Comparative study and patterns of learning styles. *Journal of Educational Technology & Society*, *18*(3), 266.

Lewis, J. R. (1995). IBM computer usability satisfaction questionnaires: psychometric evaluation and instructions for use. *International Journal of Human-Computer Interaction*, *7*(1), 57–78.

Lewis, M. P. (2009). *Ethnologue: Languages of the world*. Summer Institute of Language (SIL) International, Texas. Retrieved from http://www.ethnologue.com

Limongelli, C., Sciarrone, F., Temperini, M., & Vaste, G. (2009). Adaptive learning with the LS-plan system: a field evaluation. *IEEE Transactions on Learning Technologies*, *2*(3), 203–215.

Litzinger, T. A., Lee, S. H., & Wise, J. C. (2005). A study of the reliability and validity of the Felder-Soloman Index of Learning Styles. In *Proceedings of the 2005 American Society for Education Annual Conference & Exposition* (pp. 1–16).

Litzinger, T. A., Lee, S. H., Wise, J. C., & Felder, R. M. (2007). A psychometric study of the index of learning styles©. *Journal of Engineering Education*, *96*(4), 309.

Livesay, G. A., Dee, K. C., Nauman, E. A., & Hites Jr, L. S. (2002). Engineering student learning styles: a statistical analysis using Felder's Index of Learning Styles. In *Annual Conference of the American Society for Engineering Education, Montreal, Quebec*.

Lohr, L. (1998). Using ADDIE to design a web-based training interface. In *Society for Information Technology & Teacher Education International Conference* (pp. 452–455).

Lund, A. M. (2001). Measuring usability with the USE questionnaire. *Usability Interface*, *8*(2), 3–6. https://doi.org/10.1177/1078087402250360

Luo, L. (2001). Software testing techniques. *Institute for Software Research International Carnegie Mellon University Pittsburgh, PA*, *15232*(1–19), 19.

Mampadi, F., Chen, S. Y., Ghinea, G., & Chen, M.-P. (2011). Design of adaptive hypermedia learning systems: A cognitive style approach. *Computers & Education*, *56*(4), 1003–1011.

Mann, P. S. (2010). *Introductory statistics*. John Wiley & Sons.

Marreez, Y. M. A. H., Wells, M., Eisen, A., Rosenberg, L., Park, D., Schaller, F., … Krishna, R. (2013). Towards Integrating Basic and Clinical Sciences : Our Experience at Touro University Nevada. *Medical Science Educator*, *23*(4), 595–606. https://doi.org/10.1007/BF03341687

McCool, S. (2012). *Laravel Starter*. Packt Publishing Ltd.

McKillup, S. (2011). *Statistics explained: an introductory guide for life scientists*. Cambridge University Press.

McKimm, J., Jollie, C., & Cantillon, P. (2003). Web based learning. *Bmj*, *326*(7394), 870–873.

Melicherikova, Z., & Bušíková, A. (2012). Adaptive E-learning-A tool to overcome disadvantages of E-learning. In *Emerging eLearning Technologies & Applications (ICETA), 2012 IEEE 10th International Conference on* (pp. 263–266). IEEE.

Melis, E., & Siekmann, J. (2004). Activemath: An intelligent tutoring system for mathematics. In *International Conference on Artificial Intelligence and Soft Computing* (pp. 91–101).

Messick, S. (1987). Validity. *ETS Research Report Series*, *1987*(2), i--208.

Mishra, S., & Sharma, R. C. (2004). *Interactive multimedia in education and training*. Igi Global.

Mödritscher, F., Garcia-Barrios, V. M., & Gütl, C. (2004). The Past, the Present and the Future of adaptive E-Learning. *Proceedings of ICL 2004*.

MoEC. (2013). *Overview of the Education Sector in Indonesia 2012 - Achievements and Challenges*. Ministry of Education and Culture.

Molenda, M. (2003). In search of the elusive ADDIE model. *Performance Improvement*, *42*(5), 34–36.

Moore, J. L., Dickson-Deane, C., & Galyen, K. (2011). e-Learning, online learning, and distance learning environments: Are they the same? *The Internet and Higher Education*, *14*(2), 129–135.

Munakata, T. (2008). *Fundamentals of the new artificial intelligence: neural, evolutionary, fuzzy and more*. Springer Science & Business Media.

Myers, I. B., McCaulley, M. H., Quenk, N. L., & Hammer, A. L. (1998). *MBTI manual: A guide to the development and use of the Myers-Briggs Type Indicator* (Vol. 3). Consulting

Psychologists Press Palo Alto, CA.

National Association of State Boards of Education. (2001). *Any Time, Any Place, Any Path, Any Pace: Taking the Lead on E-learning Policy*. NASBE.

National Education Commission Learning. (1994). Prisoners of time: Report of the national education commission on time and learning. *US Government Printing Office, Washington, DC*.

Neta, R., & Pritchard, D. (2009). *Arguing about knowledge*. Routledge.

Nielsen, J. (1992). Finding usability problems through heuristic evaluation. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 373–380).

Nielsen, J. (1994). *Usability Engineering*. Elsevier.

Nielsen, J. (1995). How to conduct a heuristic evaluation. *Nielsen Norman Group*, *1*, 1–8.

Nielsen, J. (1997). The use and misuse of focus groups. *IEEE Software*, *14*(1), 94–95.

Nielsen, J., & Molich, R. (1990). Heuristic evaluation of user interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 249–256).

Nieswiadomy, R. M., & Bailey, C. (2008). Foundations of nursing research.

Nilsson, N. J., & Nilsson, N. J. (1998). *Artificial intelligence: a new synthesis*. Morgan Kaufmann.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. Oxford university press.

Norman, K., Shneiderman, B., & Harper, B. (1995). *Quis: The questionnaire for user interaction satisfaction*.

Noronha, G., Álvares, C., & Chambel, T. (2012). Sight surfers: 360°videos and maps navigation. In *Proceedings of the ACM multimedia 2012 workshop on Geotagging and its applications in multimedia* (pp. 19–22).

Nunnally, J. C. (1978). Assessment of reliability. *Psychometric Theory*, *2*, 245–246.

Nunnally, J. C., & Bernstein, I. H. (1967). *Psychometric theory* (Vol. 226). McGraw-Hill New York.

O'Leary, Z. (2017). *The essential guide to doing your research project*. Sage.

OECD/Asian Development Bank. (2015). *Education in Indonesia: Rising to the Challenge*. OECD Publishing, Paris. https://doi.org/http://dx.doi.org/10.1787/9789264230750-en

Olanrewaju, R. F., Islam, T., & Ali, N. (2015). An Empirical Study of the Evolution of PHP MVC Framework. In H. A. Sulaiman, M. A. Othman, M. F. I. Othman, Y. A. Rahim, & N. C. Pee (Eds.), *Advanced Computer and Communication Engineering Technology* (pp. 399–410). Cham: Springer International Publishing.

Olsen, H. (2002). An evaluation of Danish qualitative interview investigations. *Nordisk Psykologi*, *54*(2), 145–172.

Orfanou, K., Tselios, N., & Katsanos, C. (2015). Perceived usability evaluation of learning management systems: Empirical evaluation of the System Usability Scale. *The International Review of Research in Open and Distributed Learning*, *16*(2). https://doi.org/10.19173/irrodl.v16i2.1955

Osborne, J., & Waters, E. (2002). Four assumptions of multiple regression that researchers should always test. *Practical Assessment, Research & Evaluation*, *8*(2), 1–9.

Panko, R. R. (1998). What we know about spreadsheet errors. *Journal of Organizational and End User Computing (JOEUC)*, *10*(2), 15–21.

Papanikolaou, K. A., Grigoriadou, M., Kornilakis, H., & Magoulas, G. D. (2003). Personalizing the Interaction in a Web-based Educational Hypermedia System: the case of INSPIRE. *User Modeling and User-Adapted Interaction*, *13*(3), 213–267.

Parlangeli, O., Marchigiani, E., & Bagnara, S. (1999). Multimedia in Distance Education:Effects of Usability on Learning. *Interacting with Computers*, *1*(21), 37–49. https://doi.org/10.1016/s0953-5438(98)00054-x

Parvez, S. M. (2007). *A pedagogical framework for integrating individual learning style into an intelligent tutoring system*. Lehigh University Lehigh, PA.

Passerini, K., & Granger, M. J. (2000). A developmental model for distance learning using the Internet. *Computers & Education*, *34*(1), 1–15.

Patwardhan, M., Stoll, R., Hamel, D. B., Amresh, A., Gary, K. A., & Pina, A. (2015). Designing a mobile application to support the indicated prevention and early intervention of childhood anxiety. In *Proceedings of the conference on Wireless Health* (p. 8).

Peña, C.-I., Marzo, J.-L., & de la Rosa, J.-L. (2002). Intelligent agents in a teaching and

learning environment on the Web. In *Proceedings of the international conference on advanced learning technologies* (pp. 21–27).

Pérez, T., Gutiérrez, J., & Lopistéguy, P. (1995). An adaptive hypermedia system. In *Proceedings of AI-ED* (Vol. 95, pp. 351–358).

Peters, K. L., Selvanayaki, M., Niebling, M., Slimmer, C., Sujithra, B., Green, T., … Schumacher, R. (2009). Usability Guidance for Improving the User Interface and Adoption of Online Personal Health Records.

Piper, H., Simons, H., & others. (2005). Ethical responsibility in social research. *Research Methods in the Social Sciences*, 56–63.

Platsidou, M., & Metallidou, P. (2009). Validity and Reliability Issues of Two Learning Style Inventories in a Greek Sample: Kolb's Learning Style Inventory and Felder & Soloman's Index of Learning Styles. *International Journal of Teaching and Learning in Higher Education*, *20*(3), 324–335.

Polit, D., & Hungler, B. (1994). Essentials of nursing research: Methods, appraisal, asid utilization.

Popescu, E. (2010). Adaptation provisioning with respect to learning styles in a Web-based educational system: an experimental study. *Journal of Computer Assisted Learning*, *26*(4), 243–257.

Popescu, E., Badica, C., & Moraret, L. (2010). Accommodating learning styles in an adaptive educational system. *Informatica*, *34*(4).

Pressman, R. S. (2005). *Software engineering: a practitioner's approach*. Palgrave Macmillan.

Qureshi, I. A., Ilyas, K., Yasmin, R., & Whitty, M. (2012). Challenges of implementing e-learning in a Pakistani university. *Knowledge Management & E-Learning*, *4*(3), 310.

Rees, D. (2012). Laravel: Code Bright.

Rita, D., & Dunn, K. (1993). Learning Styles/Teaching Styles: Should They... Can They... Be Matched? *Educational Leadership*.

Rivera, J., Davis, F., Mouloua, M., & Alberti, P. (2010). Usability evaluation of two social networking sites. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 54, pp. 1421–1424).

Roberts, L. G., & Wessler, B. D. (1970). Computer network development to achieve resource sharing. In *Proceedings of the May 5-7, 1970, spring joint computer conference* (pp. 543–549).

Robinson, J. P., Shaver, P. R., & Wrightsman, L. S. (1991). Criteria for Scale Selection and Evaluation. *Measures of Personality and Social Psychological Attitudes*, *1*(3), 1–16. https://doi.org/10.1016/b978-0-12-590241-0.50005-8

Rosenberg, M. J., & Foshay, R. (2002). E-learning: Strategies for delivering knowledge in the digital age. *Performance Improvement*, *41*(5), 50–51.

Ross, S. M. (2017). *Introductory statistics*. Academic Press.

Russell, S. J., & Norvig, P. (2016). *Artificial intelligence: a modern approach*. Malaysia; Pearson Education Limited,.

Salameh, Z. (2017). Attitudes towards Facebook and the Use of Knowledge and Skills among Students in the English Department at the University of Hail. *Journal of Education and Practice*, *8*(8), 1–6.

Santos, J. L., Govaerts, S., Verbert, K., & Duval, E. (2012). Goal-oriented visualizations of activity tracking: a case study with engineering students. In *Proceedings of the 2nd international conference on learning analytics and knowledge* (pp. 143–152).

Saunier, R. (2014). *Getting started with Laravel 4*. Packt Publishing Ltd.

Sawilowsky, S. S. (2009). New effect size rules of thumb.

Schiaffino, S., Garcia, P., & Amandi, A. (2008). eTeacher: Providing personalized assistance to e-learning students. *Computers & Education*, *51*(4), 1744–1754.

Seery, N., Gaughran, W. F., & Waldmann, T. (2003). Multi-modal learning in engineering education. In *Proceedings, 2003 ASEE Conference and Exposition*.

Shelton, K., & Saltsman, G. (2011). Applying the ADDIE model to online instruction. In *Instructional design: Concepts, methodologies, tools and applications*. IGI Global.

Shute, V. J., & Psotka, J. (1994). *Intelligent Tutoring Systems: Past, Present, and Future.*

Shute, V., & Towle, B. (2003). Adaptive e-learning. *Educational Psychologist*, *38*(2), 105–114.

Simpson, E. (1971). Educational objectives in the psychomotor domain. *Behavioral Objectives in Curriculum Development: Selected Readings and Bibliography*, *60*(2).

Smith, D. (2003). Five principles for research ethics. *Monitor on Psychology*, *34*(1), 56.

Soloman, B. A., & Felder, R. M. (2005). Index of learning styles questionnaire. *NC State University. Available Online at: Http://Www.Engr.Ncsu.Edu/Learningstyles/Ilsweb.Html (Last Visited on 14.05.2010)*, *70*.

Stallings, W. (2005). Data and computer communications. *Prentice Hall*.

Stark, E., Lassiter, A. L., & Kuemper, A. (2013). A brief examination of predictors of e-learning success for novice and expert learners. *Knowledge Management & E-Learning: An International Journal*, *5*(3), 269.

Stern, M. K., & Woolf, B. P. (2000). Adaptive content in an online lecture system. In *International Conference on Adaptive Hypermedia and Adaptive Web-based Systems* (pp. 227–238).

Suciati Saputri, D., & Zuhri, D. (2015). Dorong Percepatan Pembangunan, Mendikbud akan Bangun 200 SMK. Retrieved from http://republika.co.id/berita/pendidikan/eduaction/nkksio/dorong-percepatan-pembangunan-mendikbud-akan-bangun-200-smk

Suen, H. K., & Ary, D. (2014). *Analyzing quantitative behavioral observation data*. psychology press.

Surjono, H. D. (2007). Empirical evaluation of an adaptive e-learning system and the effects of knowledge, learning styles and multimedia mode on student achievement. In *UiTM International Conference on ELearning*.

Thompson, J., & Soyibo, K. (2002). Effects of lecture, teacher demonstrations, discussion and practical work on 10th graders' attitudes to chemistry and understanding of electrolysis. *Research in Science & Technological Education*, *20*(1), 25–37.

Timmermans, A. A. A., Seelen, H. A. M., Geers, R. P. J., Saini, P. K., Winter, S., te Vrugt, J., & Kingma, H. (2010). Sensor-based arm skill training in chronic stroke patients: results on treatment outcome, patient motivation, and system usability. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, *18*(3), 284–292.

Triacca, L., Bolchini, D., Botturi, L., & Inversini, A. (2004). Mile: Systematic usability evaluation for e-Learning web applications. In *EdMedia+ Innovate Learning* (pp. 4398–

4405).

Triantafillou, E., Pomportsis, A., & Demetriadis, S. (2003). The design and the formative evaluation of an adaptive educational system based on cognitive styles. *Computers & Education*, *41*(1), 87–103.

Tsiatsos, T., Douka, S., Zimmer, T., & Geoffroy, D. (2014). Evaluation Plan of a network of remote labs in the Maghrebian countries. In *2014 11th International Conference on Remote Engineering and Virtual Instrumentation (REV)* (pp. 200–203).

Van Teijlingen, E. R., & Hundley, V. (2001). The importance of pilot studies.

Van Zwanenberg, N., Wilkinson, L. J., & Anderson, A. (2000). Felder and Silverman's Index of Learning Styles and Honey and Mumford's Learning Styles Questionnaire: how do they compare and do they predict academic performance? *Educational Psychology*, *20*(3), 365–380.

Vanmulken, D., Spooren, A. I. F., Bongers, H. M. H., & Seelen, H. A. M. (2015). Robot-assisted task-oriented upper extremity skill training in cervical spinal cord injury: a feasibility study. *Spinal Cord*, *53*(7), 547.

Vaughan, T. (2011). Multimedia: Making It Work (w/CD).

Velázquez, A. L. F., & Assar, S. (2007). Using learning styles to enhance an e-learning system. In *Sixth European conference on e-learning. Copenhagen, Denmark*.

Vincent, A., & Ross, D. (2001). Personalize training: determine learning styles, personality types and multiple intelligences online. *The Learning Organization*, *8*(1), 36–43.

Wallace, S., Reid, A., Clinciu, D., & Kang, J.-S. (2013). Culture and the importance of usability attributes. *Information Technology & People*, *26*(1), 77–93.

Wallace, S., & Yu, H.-C. (2009). The effect of culture on usability: Comparing the perceptions and performance of Taiwanese and North American MP3 player users. *Journal of Usability Studies*, *4*(3), 136–146.

Walsh, W. B., & Betz, N. E. (1995). *Tests and assessment*. Prentice-Hall, Inc.

Wang, J., Zhu, J., Ye, S., Li, J., Liang, H. Q., Liu, Y., & Zuo, Y. N. (2010). Editing, creating, and verifying reorganization of flowchart, and transforming between flowchart and tree diagram. Google Patents.

Wang, T., & Dolezel, D. (2016). Usability of Web-based Personal Health Records: An Analysis of Consumers' Perspectives. *Perspectives in Health Information Management*, *13*(Spring).

Weber, G., & Brusilovsky, P. (2001). ELM-ART: An adaptive versatile system for Web-based instruction.

Whitby, B. (2009). *Artificial intelligence*. The Rosen Publishing Group, Inc.

Williams, L. (2006). Testing overview and black-box testing techniques. *Retrieved Agustus*, *12*, 2015.

Winston, P. H., & Brown, R. H. (1984). *Artificial Intelligence, an MIT Perspective*. MIT Press.

Witkin, H. A., Moore, C. A., Goodenough, D. R., & Cox, P. W. (1977). Field-dependent and field-independent cognitive styles and their educational implications. *ETS Research Bulletin Series*, *1977*(2), 1–64.

Wolf, C. (2003). iWeaver: towards' learning style'-based e-learning in computer science education. In *Proceedings of the fifth Australasian conference on Computing education-Volume 20* (pp. 273–279).

Wonnacott, T. H., & Wonnacott, R. J. (1990). *Introductory statistics* (Vol. 5). Wiley New York.

Zarabzadeh, A., McDonnell, R., Berrios, S. P., Dempsey, J., Harrington, E., Smith, S. M., & Fahey, T. (2016). Utility of electronic international register of clinical prediction rules relevant to primary care. In *2016 IEEE 29th International Symposium on Computer-Based Medical Systems (CBMS)* (pp. 146–151).

Zywno, M. S. (2003). A contribution to validation of score meaning for Felder-Soloman's index of learning styles. In *Proceedings of the 2003 American Society for Engineering Education annual conference & exposition* (Vol. 119, pp. 1–5). American Society for Engineering Education Washington, DC.

APPENDIX A:

CONTENT ASPECT QUESTIONNAIRE BY SUBJECT-BASED EXPERT

Dear Sir/Madam,

I am a Ph.D. student at the Institute of Vocational Education, Dresden University of Technology, Germany. Currently, I am conducting research about An Adaptive E-learning System based on Student's Learning Style and Initial Knowledge. One of the main aims of my study is to develop an adaptive e-learning system by accommodating students' learning style and initial knowledge. There are two variables used in the system as references on adaptation. The first one is the students' learning style, and the second is the students' initial knowledge. The background of my research comes from the fact that every student has his or her learning style preferences. The system has the ability to automatically adapt by changing its learning environment based on those both learning style and initial knowledge.

One of my research stages is getting the assessment in terms of the material content of my e-learning system prototype that I have been developed. Therefore, I would be pleased if you would complete the questionnaire by putting a tick to the agreement and disagreement scale for each statement prepared. In the last section of the questionnaire, please give comments, suggestions, or recommendations that will help to improve the adaptive e-learning application.

Thank you very much for your kind consideration and valuable contribution in this respect. If you need additional information, don't hesitate to contact me.

Yours sincerely,

Didik Hariyanto
Ph.D. Students at Institute of Vocational Education,
Faculty of Education, Dresden University of Technology, Germany.

Angket Penilaian Materi oleh Ahli Materi

Material Review Questionnaire by Material Expert

No	Pernyataan (*Statements*)	Jawaban (*Answer*) *)			
		STS	TS	S	SS
Substansi Materi (*Material Substance*)					
1	Materi sudah sesuai dengan kaidah keilmuan. *The material is in accordance with scientific rules.*				
2	Materi bersifat faktual. *The material is factual.*				
3	Materi bersifat rasional dan logis. *The material is rational and logical.*				
4	Materi disajikan sesuai dengan kompetensi dasar. *The material is presented in accordance with the basic competencies.*				
5	Materi terkait dengan mata pelajaran lain. *The material has a relationship with other subjects.*				
6	Materi tersusun berdasarkan perkembangan ilmu pengetahuan dan teknologi (iptek) yang terbaru (up-to-date). *The material is organized on the basis of the latest state of science and technology.*				
7	Materi bersifat inovatif. *The material is innovative.*				
8	Bahasa yang digunakan sudah sesuai standar (baku). *The language used is standard.*				
9	Materi mudah untuk dipahami. *The material is easy to understand.*				
Desain Pembelajaran (*Learning Design*)					
10	Judul yang digunakan sudah sesuai dengan cakupan materi. *The title used matches the subject matter.*				
11	Materi yang ditampilkan sesuai dengan kompetensi inti. *The material displayed in accordance with the core competencies.*				
12	Materi yang ditampilkan sesuai dengan kompetensi dasar. *The material displayed in accordance with the basic competencies.*				
13	Materi yang ditampilkan sesuai dengan tujuan pembelajaran. *The material displayed in accordance with the learning objectives.*				

No	Pernyataan (*Statements*)	Jawaban (*Answer*) *)			
		STS	TS	S	SS
14	Contoh soal disajikan pada setiap materi. *Examples are presented on each unit.*				
15	Contoh soal disusun sesuai dengan materi. *Examples are arranged according to the material.*				
16	Latihan soal diberikan pada setiap materi. *Exercises are given on each unit.*				
17	Latihan soal disusun sesuai dengan materi. *Exercises are organized in accordance with the material.*				
18	Terdapat informasi identitas penyusun. *There is information about the author.*				
19	Terdapat informasi sumber referensi. *There is a reference.*				

Keterangan (*note*):

STS : Sangat Tidak Setuju (*strongly not agree*)
TS : Tidak Setuju (*not agree*)
S : Setuju (*agree*)
SS : Sangat Setuju (*strongly agree*)

Komentar dan Saran (*comments and suggestions*):

……
……
……
……
……
……
……
……
……
……
……
……
……
……
……
……
……
……

Kesimpulan (*conclusion*):

Setelah dilakukan kajian yang mendalam, aplikasi *"An Adaptive E-learning System based on Student's Learning Style and Initial Knowledge"* dapat dinyatakan:

After a careful review, the application of "An Adaptive E-learning System based on Student's Learning Style and Initial Knowledge" is classified as: *)

- ☐ Layak digunakan tanpa perbaikan (*feasible to use without any revision*)
- ☐ Layak digunakan dengan perbaikan (*feasible to use with certain revision*s)
- ☐ Tidak layak digunakan (*not feasible to use*)

Yogyakarta, …… 2017

_____

Nama dan tanda tangan

Name and signature of the validator

Catatan (*note*):

*) beri tanda centang pada pilihan yang dianggap benar (*tick the appropriate one*)

APPENDIX B:

LEARNING MEDIA QUESTIONNAIRE BY MEDIA EXPERT

Dear Sir/Madam,

I am a Ph.D. student at the Institute of Vocational Education, Dresden University of Technology, Germany. Currently, I am conducting research about An Adaptive E-learning System based on Student's Learning Style and Initial Knowledge. One of the main aims of my study is to develop an adaptive e-learning system by accommodating students' learning style and initial knowledge. There are two variables used in the system as references on adaptation. The first one is the students' learning style, and the second is the students' initial knowledge. The background of my research comes from the fact that every student has his or her learning style preferences. The system has the ability to automatically adapt by changing its learning environment based on those both learning style and initial knowledge.

One of my research stages is getting the assessment in terms of the media used in my e-learning system prototype that I have been developed. Therefore, I would be pleased if you would complete the questionnaire by putting a tick to the agreement and disagreement scale for each statement prepared. In the last section of the questionnaire, please give comments, suggestions, or recommendations that will help to improve the adaptive e-learning application.

Thank you very much for your kind consideration and valuable contribution in this respect. If you need additional information, don't hesitate to contact me.

Yours sincerely,

Didik Hariyanto
Ph.D. Students at Institute of Vocational Education,
Faculty of Education, Dresden University of Technology, Germany.

Angket Penilaian Media oleh Ahli Media

Media Review Questionnaire by Media Expert

No	Pernyataan (*Statements*)	Jawaban (*Answer*) *)			
		STS	TS	S	SS
Tampilan Komunikasi Visual (*Visual Interface*)					
1	Tombol navigasi tersedia di setiap halaman. *Navigation buttons are available on each pages.*				
2	Perpindahan dari satu halaman ke halaman lain mudah untuk dilakukan. *Easy to move from one page to another.*				
3	Tombol navigasi mudah untuk dioperasikan. *The navigation buttons are easy to operate.*				
4	Tombol navigasi berfungsi dengan baik. *The navigation buttons are well functioned.*				
5	Jenis huruf yang digunakan membuat materi jelas terbaca. *The font styles used make the material clearly to read.*				
6	Ukuran huruf yang digunakan proporsional. *The font sizes used are proportional.*				
7	Warna huruf yang digunakan nyaman untuk dilihat. *The font colors used is comfortable.*				
8	Kualitas gambar baik sehingga dapat dilihat dengan jelas. *The image quality is good so it can be seen clearly.*				
9	Kualitas suara sudah baik. *The sound quality in overall is good.*				
10	Informasi dapat didengar dengan baik. *Information can be heard clearly.*				
11	Animasi/Video yang digunakan mendukung penyampaian materi. *Animations/Videos used are appropriate to support the material.*				
12	Animasi/Video yang digunakan membantu pemahaman siswa. *Animations/Videos used help student understanding.*				
13	Komposisi warna secara keseluruhan sudah tepat. *The color composition in overall is appropriate.*				
14	Tata letak secara keseluruhan sudah proporsional. *The layout in overall is proportional.*				

No	Pernyataan (*Statements*)	Jawaban (*Answer*) *)			
		STS	TS	S	SS
15	Tata letak antara teks dan media (grafis, animasi, video, dan panel suara) sudah baik. *The layout between text and media (graphics, animation, video, and sound panels) is good.*				
16	Peletakan tombol navigasi mudah untuk diakses. *The layout of the navigation buttons is easy to access.*				
Pemanfaatan Media Pembelajaran (*Learning Media Utilization*)					
17	Aplikasi ini mudah untuk digunakan. *This application is easy to use.*				
18	Terdapat umpan balik hasil tes. *There is a feedback on test results.*				
19	Perangkat lunak pendukung mudah didapatkan. *The software supports are easy to get.*				
20	Informasi tentang tim pengembang dicantumkan dalam aplikasi ini. *The information about the developer team is included in this application*				

Keterangan (*note*):

STS : Sangat Tidak Setuju (*strongly not agree*)
TS : Tidak Setuju (*not agree*)
S : Setuju (*agree*)
SS : Sangat Setuju (*strongly agree*)

Komentar dan Saran (*comments and suggestions*):

……
……
……
……
……
……
……
……
……
……
……
……

Kesimpulan (*conclusion*):

Setelah dilakukan kajian yang mendalam, aplikasi *"An Adaptive E-learning System based on Student's Learning Style and Initial Knowledge"* dapat dinyatakan:

After a careful review, the application of "An Adaptive E-learning System based on Student's Learning Style and Initial Knowledge" is classified as: *)

- ☐ Layak digunakan tanpa perbaikan (*feasible to use without any revision*)
- ☐ Layak digunakan dengan perbaikan (*feasible to use with certain revision*s)
- ☐ Tidak layak digunakan (*not feasible to use*)

Yogyakarta, …… 2017

_____

Nama dan tanda tangan

Name and signature of the validator

Catatan (*note*):

*) beri tanda centang pada pilihan yang dianggap benar (*tick the appropriate one*)

APPENDIX C:

APPLICATION REVIEW QUESTIONNAIRE BY USER (STUDENTS)

Kepada siswa-siswi, (*Dear Students,*)

Berikut ini adalah kuesioner untuk mendapatkan tanggapan berdasarkan keyakinan Anda terhadap aplikasi e-learning adaptif yang kami kembangkan.

The following is the questionnaire to get the response from your personal beliefs for the adaptive e-learning application we developed.

Kuesioner ini disusun terdiri dari tiga bagian. Bagian pertama meminta Anda untuk memberikan tanda centang pada skala jawaban yang disediakan berdasarkan respons Anda setelah menggunakan aplikasi e-learning adaptif. Bagian kedua meminta Anda untuk memberikan komentar atau saran terbuka untuk aplikasi e-learning adaptif. Bagian ketiga meminta Anda memberikan informasi tentang identitas pribadi Anda.

The questionnaire is divided into three parts. The first part asks you to put a tick on the agreement and disagreement scale based on your personal response after you have experienced with the adaptive e-learning application. The second part asks you to provide comments or suggestions on the basis of open feedback for the adaptive e-learning application. The third part asks you for information about your personal identity.

Terima kasih banyak atas kontribusi Anda yang berharga dalam penelitian ini.

Thank you very much for your valuable contribution in this respect.

Salam, (*Regards,*)

Didik Hariyanto
Ph.D. Students at Institute of Vocational Education,
Faculty of Education, Dresden University of Technology, Germany.

Angket Penilaian Aplikasi oleh Siswa

Application Review Questionnaire by User (Students)

No	Pernyataan (*Statements*)	Jawaban (*Answer*) *)			
		STS	TS	S	SS
Kebermanfaatan (*Usefulness*)					
1	Aplikasi ini membantu untuk lebih efektif dalam belajar. *This application helps to be more effective in learning.*				
2	Aplikasi ini membantu untuk lebih produktif dalam belajar. *This application helps to be more productive in learning.*				
3	Aplikasi ini berguna dalam proses pembelajaran. *This application is useful in the learning process.*				
4	Aplikasi ini memberikan kendali lebih luas dalam belajar. *This application gives more control over the learning activities.*				
5	Aplikasi ini membuat permasalahan menjadi **lebih sulit** untuk diselesaikan. *This application makes the things want to accomplish **more difficult** to get done.*				
6	Aplikasi ini dapat menghemat waktu dalam belajar. *This application saves time in learning.*				
7	Aplikasi ini sesuai dengan yang dibutuhkan siswa. *This application meets the students' needs.*				
8	Aplikasi ini sesuai dengan yang diharapkan siswa. *This application does everything would expect it to do.*				
Kemudahan dalam Pengoperasian (*Ease of Use*)					
9	Aplikasi ini mudah untuk dioperasikan. *This application is easy to use.*				
10	Aplikasi ini sederhana untuk digunakan. *This application is simple to use.*				
11	Aplikasi ini user-friendly (mudah digunakan oleh pengguna). *This application is user friendly.*				
12	Aplikasi ini praktis untuk digunakan. *This application requires the fewest steps possible to accomplish what want to do with it.*				

No	Pernyataan (*Statements*)	Jawaban (*Answer*) *)			
		STS	TS	S	SS
13	Aplikasi ini fleksibel untuk digunakan. *This application is flexible.*				
14	Dibutuhkan **usaha yang sulit** untuk menggunakan aplikasi ini. *It takes **many effort** to use this application.*				
15	Aplikasi ini dapat digunakan tanpa adanya panduan tertulis. *This application can be used without written instructions.*				
16	Tidak ditemukan adanya ketidakkonsistenan dalam aplikasi ini. *There is no any inconsistency in this application.*				
17	Pengguna dari semua tingkat kemampuan dapat menyukai aplikasi ini. *Both occasional and regular users would like it.*				
18	Pengguna dapat kembali dengan cepat dan mudah pada saat melakukan kesalahan. *Users can recover from mistakes quickly and easily.*				
19	Aplikasi ini dapat digunakan dengan baik setiap waktu. *This application can be used successfully every time.*				
Kemudahan dalam Belajar (*Ease of Learning*)					
20	Pengguna dapat dengan cepat mengetahui cara menggunakan aplikasi ini. *Users can learn to use it quickly.*				
21	Pengguna dengan mudah mengingat cara mengoperasikan aplikasi ini. *Users easily remember how to use it.*				
22	Aplikasi ini mudah untuk dipelajari cara menggunakannya. *This application is easy to learn to use it.*				
23	Pengguna dapat dengan cepat untuk terampil menggunakan aplikasi ini. *Users quickly became skillful with it.*				
Kepuasan (*Satisfaction*)					
24	Aplikasi ini membuat pengguna merasa puas untuk menggunakannya. *This application can make users satisfied with it.*				
25	Aplikasi ini dapat direkomendasikan ke orang lain. *This application can be recommended to a friend.*				

No	Pernyataan (*Statements*)	Jawaban (*Answer*) *)			
		STS	TS	S	SS
26	Aplikasi ini **tidak** menyenangkan untuk digunakan. *This application is **not** fun to use.*				
27	Aplikasi ini bekerja seperti yang diinginkan. *This application works the way as it want to work.*				
28	Aplikasi ini bekerja dengan luar biasa. *This application is wonderful.*				
29	Aplikasi ini harus dimiliki oleh siswa. *This application should be had by students.*				
30	Aplikasi ini nyaman untuk digunakan. *This application is pleasant to use.*				

Keterangan (*note*):

STS : Sangat Tidak Setuju (*strongly not agree*)
TS : Tidak Setuju (*not agree*)
S : Setuju (*agree*)
SS : Sangat Setuju (*strongly agree*)

Komentar dan Saran (*comments and suggestions*):

……
……
……
……
……
……
……

Identitas Responden (*Respondent Identity*):

Nama (*Name*) : ……
Kelas (*Class*) : ……
NIS (*Registration Number*) : ……

Yogyakarta, …… 2017

_____
tandatangan (*signature*)

Catatan (*note*):

*) beri tanda centang pada pilihan yang dianggap benar (*tick the appropriate one*)

APPENDIX D:

LEARNING STYLE QUESTIONNAIRE (ENGLISH VERSION)

Students' Learning Style Questionnaire

by:
Barbara A. Soloman and Richard M. Felder
North Carolina State University

Full Name : .....

Grade : .....

Place & Date of Birth : .....

Gender : Male / Female (cross out whichever does not apply)

Time Duration (hh:mm) : a. Start filling out the questionnaire ..... : .....

b. Finished filling out the questionnaire ..... : .....

Instructions:

Choose one of the following answers that is considered the most appropriate one based on your opinion by giving a cross (x) on one of the answer choices "a" or "b".

1. I understand something better after I
   a. try it out.
   b. think it through.

2. I would rather be considered
   a. realistic.
   b. innovative.

3. When I think about what I did yesterday, I am most likely to get
   a. a picture.
   b. words.

4. I tend to
   a. understand details of a subject but may be fuzzy about its overall structure.
   b. understand the overall structure but may be fuzzy about details.

5. When I am learning something new, it helps me to
   a. talk about it.
   b. think about it.

6. If I were a teacher, I would rather teach a course
   a. that deals with facts and real life situations.
   b. that deals with ideas and theories.

7. I prefer to get new information in
   a. pictures, diagrams, graphs, or maps.
   b. written directions or verbal information.

8. Once I understand
   a. all the parts, I understand the whole thing.
   b. the whole thing, I see how the parts fit.

9. In a study group working on difficult material, I am more likely to
   a. jump in and contribute ideas.
   b. sit back and listen.

10. I find it easier
    a. to learn facts.
    b. to learn concepts.

11. In a book with lots of pictures and charts, I am likely to
    a. look over the pictures and charts carefully.
    b. focus on the written text.

12. When I solve math problems
    a. I usually work my way to the solutions one step at a time.
    b. I often just see the solutions but then have to struggle to figure out the steps to get to them.

13. In classes I have taken
    a. I have usually gotten to know many of the students.
    b. I have rarely gotten to know many of the students.

14. In reading nonfiction, I prefer
    a. something that teaches me new facts or tells me how to do something.
    b. something that gives me new ideas to think about.

15. I like teachers
    a. who put a lot of diagrams on the board.
    b. who spend a lot of time explaining.

16. When I'm analyzing a story or a novel
    a. I think of the incidents and try to put them together to figure out the themes.
    b. I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

17. When I start a homework problem, I am more likely to
    a. start working on the solution immediately.
    b. try to fully understand the problem first.

18. I prefer the idea of
    a. certainty.
    b. theory.

19. I remember best
    a. what I see.
    b. what I hear.

20. It is more important to me that an instructor
    a. lay out the material in clear sequential steps.
    b. give me an overall picture and relate the material to other subjects.

21. I prefer to study
    a. in a study group.
    b. alone.

22. I am more likely to be considered
    a. careful about the details of my work.
    b. creative about how to do my work.

23. When I get directions to a new place, I prefer
    a. a map.
    b. written directions.

24. I learn
    a. at a fairly regular pace. If I study hard, I'll “get it.”
    b. in fits and starts. I'll be totally confused and then suddenly it all “clicks.”

25. I would rather first
    a. try things out.
    b. think about how I'm going to do it.

26. When I am reading for enjoyment, I like writers to
    a. clearly say what they mean.
    b. say things in creative, interesting ways.

27. When I see a diagram or sketch in class, I am most likely to remember
    a. the picture.
    b. what the instructor said about it.

28. When considering a body of information, I am more likely to
    a. focus on details and miss the big picture.
    b. try to understand the big picture before getting into the details.

29. I more easily remember
    a. something I have done.
    b. something I have thought a lot about.

30. When I have to perform a task, I prefer to
    a. master one way of doing it.
    b. come up with new ways of doing it.

31. When someone is showing me data, I prefer
    a. charts or graphs.
    b. text summarizing the results.

32. When writing a paper, I am more likely to
    a. work on (think about or write) the beginning of the paper and progress forward
    b. work on (think about or write) different parts of the paper and then order them.

33. When I have to work on a group project, I first want to
    a. have “group brainstorming” where everyone contributes ideas.
    b. brainstorm individually and then come together as a group to compare ideas.

34. I consider it higher praise to call someone
    a. sensible.
    b. imaginative.

35. When I meet people at a party, I am more likely to remember
    a. what they looked like.
    b. what they said about themselves.

36. When I am learning a new subject, I prefer to
    a. stay focused on that subject, learning as much about it as I can.
    b. try to make connections between that subject and related subjects.

37. I am more likely to be considered
    a. outgoing.
    b. reserved.

38. I prefer courses that emphasize
    a. concrete material (facts, data).
    b. abstract material (concepts, theories).

39. For entertainment, I would rather
    a. watch television.
    b. read a book.

40. Some teachers start their lectures with an outline of what they will cover. Such outlines are
    a. somewhat helpful to me.
    b. very helpful to me.

41. The idea of doing homework in groups, with one grade for the entire group,
    a. appeals to me.
    b. does not appeal to me.

42. When I am doing long calculations,
    a. I tend to repeat all my steps and check my work carefully.
    b. I find checking my work tiresome and have to force myself to do it.

43. I tend to picture places I have been
    a. easily and fairly accurately.
    b. with difficulty and without much detail.

44. When solving problems in a group, I would be more likely to
    a. think of the steps in the solutions process.
    b. think of possible consequences or applications of the solution in a wide range of areas.

:: Thank you very much for your willingness to fill out this Questionnaire. ::

APPENDIX E:

LEARNING STYLE QUESTIONNAIRE (INDONESIAN VERSION)

Kuesioner Gaya Belajar Siswa

Oleh:
Barbara A. Soloman dan Richard M. Felder
North Carolina State University

Nama Lengkap : .....

Kelas : .....

Tempat/Tanggal Lahir : .....

Jenis Kelamin : Laki-Laki / Perempuan (coret yang tidak perlu)

Waktu : a. Mulai mengisi angket ..... (tuliskan jam dan menit)

b. Selesai mengisi angket ..... (tuliskan jam dan menit)

Petunjuk:

Pilihlah salah satu jawaban yang dianggap paling tepat atau paling sesuai menurut pendapat Anda dengan memberikan tanda silang (x) pada salah satu pilihan jawaban ”a” atau ”b”.

1. Saya lebih memahami sesuatu setelah
   a. mencobanya.
   b. memikirkannya masak-masak.

2. Saya lebih suka dianggap
   a. realistis.
   b. inovatif.

3. Bila saya berpikir tentang apa yang saya lakukan pada hari kemarin, yang paling memungkinkan bagi saya adalah akan mendapatkan
   a. suatu bayangan.
   b. kata-kata.

4. Saya cenderung
   a. memahami sesuatu dari detailnya dan merasa tidak jelas tentang struktur keseluruhannya.
   b. memahami struktur keseluruhannya dan merasa tidak jelas tentang detailnya.

5. Bila saya sedang belajar sesuatu yang baru, saya akan merasa terbantu kalau
   a. berbicara tentangnya.
   b. berpikir tentangnya.

6. Andai saya seorang guru, saya akan lebih suka mengajarkan suatu program pengajaran
   a. yang berurusan dengan fakta-fakta dan situasi-situasi di kehidupan nyata.
   b. yang berurusan dengan ide-ide dan teori-teori.

7. Saya lebih suka memperoleh informasi baru dari
   a. sejumlah gambar, bagan, grafik atau denah.
   b. petunjuk tertulis atau informasi lisan.

8. Di saat saya memahami .....
   a. semua bagiannya, saya kemudian akan memahami keseluruhannya.
   b. keseluruhannya, saya akan melihat bagaimana bagian per bagiannya bisa cocok satu sama lain.

9. Dalam suatu kelompok belajar yang sedang mengerjakan materi yang sulit, saya lebih mungkin
   a. langsung terjun dan menyumbangkan ide-ide.
   b. duduk dan mendengarkan.

10. Saya lebih mudah
    a. mempelajari fakta-fakta.
    b. mempelajari konsep-konsep.

11. Menghadapi sebuah buku dengan banyak unsur non-tulisan seperti gambar dan lain-lain, saya akan
    a. memeriksa gambar-gambar dan lain-lain itu dengan seksama.
    b. fokus pada teks tertulis.

12. Ketika mengerjakan soal matematika
    a. saya biasanya bekerja langkah demi langkah untuk sampai pada hasilnya.
    b. saya sering langsung mengetahui hasilnya tetapi kemudian harus berjuang untuk mengetahui langkah-langkah untuk memperolehnya.

13. Dalam kelas yang telah saya ikuti
    a. saya biasanya kenal dengan banyak siswa lainnya.
    b. saya jarang kenal dengan siswa lainnya.

14. Dalam membaca bacaan non-fiksi (yang bukan cerita atau novel), saya lebih menyukai
    a. sesuatu yang mengajarkan fakta-fakta baru kepada saya atau memberitahu saya bagaimana melakukan sesuatu.
    b. sesuatu yang memberi saya ide-ide baru untuk dipikirkan.

15. Saya menyukai guru
    a. yang menampilkan banyak bagan di papan.
    b. yang waktu mengajarnya di kelas banyak digunakan untuk menjelaskan.

16. Bila saya sedang menganalisis suatu cerita atau suatu novel
    a. saya berpikir tentang peristiwa-peristiwanya dan berusaha menyatukannya untuk mengetahui tema-temanya.
    b. saya baru mengetahui tema-temanya ketika selesai membaca dan kemudian harus kembali dan menemukan peristiwa-peristiwa yang memperlihatkan tema-tema itu.

17. Bila saya mulai mengerjakan suatu soal pekerjaan rumah, saya lebih mungkin
    a. segera mulai bekerja untuk menjawab soal tersebut.
    b. lebih dahulu berusaha sepenuhnya memahami soal tersebut.

18. Saya lebih menyukai pemikiran tentang
    a. sesuatu yang sudah pasti.
    b. sesuatu yang masih teori.

19. Saya paling baik mengingat
    a. yang saya lihat.
    b. yang saya dengar.

20. Bagi saya lebih penting kalau seorang guru
    a. mengatur materinya dalam langkah-langkah yang berurutan dan jelas.
    b. memberi saya suatu gambaran menyeluruh dan mengaitkan materinya dengan pelajaran-pelajaran lain.

21. Saya lebih menyukai belajar
    a. dalam kelompok belajar.
    b. sendirian.

22. Saya lebih mungkin dianggap
    a. cermat dalam menangani detail-detail pekerjaan saya.
    b. kreatif dalam melakukan pekerjaan saya.

23. Untuk mendapatkan petunjuk arah ke suatu tempat yang baru bagi saya, saya lebih menyukai diberi
    a. sebuah denah.
    b. instruksi-instruksi tertulis.

24. Saya belajar dengan
    a. kecepatan yang cukup teratur. Kalau belajar dengan keras, saya akan mendapat hasil.
    b. sering berhenti dan mulai lagi. Saya akan bingung total dan lalu mendadak semuanya menjadi jelas.

25. Saya lebih suka pertama-tama
    a. mencoba-coba dalam melakukan sesuatu.
    b. berpikir tentang bagaimana saya akan melakukannya.

26. Bilamana saya sedang membaca sebuah buku, saya menyukai penulis-penulis yang
    a. dengan jelas mengatakan maksud mereka.
    b. mengatakan segala sesuatunya secara kreatif dan menarik.

27. Bila melihat suatu bagan atau sketsa di kelas, paling mungkin saya akan mengingat
    a. gambar tersebut.
    b. kata-kata guru yang menjelaskan tentang gambar tersebut.

28. Dalam menanggapi informasi dengan jumlah tertentu, saya lebih mungkin akan
    a. fokus pada detail dan tak menangkap gambaran besarnya.
    b. berusaha memahami gambaran besarnya sebelum menuju ke detailnya.

29. Saya lebih mudah mengingat
    a. sesuatu yang telah saya lakukan.
    b. sesuatu yang telah saya pikirkan.

30. Bila harus melaksanakan suatu tugas, saya lebih suka
    a. menguasai satu cara melakukannya.
    b. menemukan cara-cara baru untuk melakukannya.

31. Saya lebih suka bila seseorang memperlihatkan data kepada saya dalam bentuk
    a. bagan-bagan atau grafik-grafik.
    b. teks yang memberi ringkasan hasil-hasilnya.

32. Bila menulis makalah, saya lebih mungkin
    a. mengerjakan (memikirkan atau menuliskan) bagian permulaan makalah itu dan diteruskan ke bagian-bagian selanjutnya.
    b. mengerjakan (memikirkan atau menuliskan) bagian per bagian makalah itu dan kemudian mengurutkannya.

33. Bila harus mengerjakan proyek kelompok, saya ingin pertama-tama
    a. diadakan pencarian ide dalam kelompok dengan setiap orang menyumbangkan ide-ide.
    b. mencari ide sendiri-sendiri dan menyatu menjadi kelompok untuk membandingkan ide-ide.

34. Saya anggap pemberian pujian kepada seseorang bila menyebut seseorang
    a. berakal sehat.
    b. berpandangan baru.

35. Tatkala bertemu dengan orang banyak di suatu pesta, saya lebih mungkin akan mengingat
    a. rupa dan penampilan mereka.
    b. cerita mereka tentang diri mereka.

36. Ketika sedang belajar suatu hal baru, saya lebih suka
    a. tetap fokus pada hal itu dan belajar sebanyak saya bisa tentangnya.
    b. berusaha menghubungkan hal itu dengan hal-hal lain yang terkait.

37. Saya lebih mungkin dianggap
    a. ramah/suka bergaul.
    b. pendiam/introvert.

38. Saya lebih menyukai program pembelajaran yang menekankan
    a. materi kongkrit (fakta-fakta, data-data).
    b. materi abstrak (konsep-konsep, teori-teori).

39. Untuk hiburan, saya lebih suka
    a. menonton TV.
    b. membaca buku.

40. Beberapa guru memulai pelajaran dengan memberi suatu garis besar mengenai yang akan mereka jelaskan. Garis besar semacam itu
    a. sedikit membantu saya.
    b. sangat membantu saya.

41. Pemikiran tentang mengerjakan pekerjaan rumah sebagai kerja kelompok, dengan satu nilai untuk seluruh kelompok, bagi saya
    a. menarik.
    b. tidak menarik.

42. Ketika sedang mengerjakan perhitungan-perhitungan yang panjang,
    a. saya cenderung mengulang-ulang semua langkah saya dan mengecek pekerjaan saya dengan cermat.
    b. kegiatan mengecek pekerjaan terasa menjengkelkan dan saya harus memaksa diri untuk melakukannya.

43. Saya cenderung menggambarkan atau membayangkan tempat-tempat yang pernah saya kunjungi
    a. dengan mudah dan cukup akurat.
    b. dengan sukar dan tanpa banyak detail.

44. Ketika mengatasi masalah dalam kerja kelompok, saya akan lebih mungkin
    a. berpikir tentang langkah-langkah dalam proses pemecahan masalah.
    b. berpikir tentang berbagai kemungkinan konsekuensi atau aplikasi pemecahan masalah itu dalam wilayah-wilayah yang luas rentangannya.

:: Terima kasih banyak atas kesediaan Anda mengisi Kuesioner ini. ::

APPENDIX F:

THE ACHIEVEMENT TEST (ENGLISH VERSION)

Achievement Test

Subjects : Digital Simulation and Communication
Group : X TKJ
Semester : Genap
Duration : 45 minutes

Full Name : .....
Student ID Number : .....
Class : .....
Time Duration (hh:mm) : a. Start test ..... : .....
b. Finished test ..... : .....

Instructions:

Choose one of the correct answers by giving a cross (x) to one of the choices!

1. Among the following choices, which one is more appropriate to describe the virtual class?
   a. A class meeting which is held without face-to-face communication between teacher and student
   b. A class meeting which is intended for students whose the learning process is accelerated according to the level of understanding
   c. The range or distance between classes is in sequence order
   d. A class meeting which is held without any internet connection
   e. A class meeting where students do not use equipment as media

2. The following includes the primary keys in the use of information and communication technology (ICT) in the context of the learning revolution, except ...
   a. Connectivity
   b. Flexibility
   c. Interaction
   d. Collaboration
   e. Limitation

3. The term of a virtual class is generally understood by many people, this is one example of information technology application in the field of .....
   a. Social and culture
   b. Media social
   c. Education
   d. Computer science
   e. Politic

4. Several experts have the same understanding of e-learning definition. Among the following choices, which one can describe the most appropriate definition of e-learning .....
   a. Learning process by utilizing conventional media
   b. Learning process by utilizing conventional book
   c. Learning process by utilizing effective technology
   d. Learning process by utilizing sophisticated technology
   e. Learning process by utilizing information and communication technology (ICT)

5. The following are e-learning models according to Rashty (1999), except .....
   a. Adjunct model
   b. Conventional model
   c. Mixed model
   d. Fully Online model
   e. Blended model

6. If the learning process wants to be conducted through e-learning mechanism, there are several tools and materials to be prepared to ensure the e-learning application run well. Among the following answers, which one is not included in the components needed in e-learning .....
   a. hardware
   b. software
   c. freeware
   d. computer network infrastructure
   e. learning content

7. There are various kinds of terms used in virtual class applications. The following are the types included in the virtual class, except .....
   a. Learning Management System (LMS)
   b. Learning Content Management System
   c. Social Learning Network (SLN)
   d. Social Media (Socmed)
   e. Computer Supported Social Learning (CSSL)

8. Among the following choices, which one is not included in the example of the Social Learning Network (SLN) .....
   a. Network
   b. Einztein
   c. Sophia
   d. RemixLearning
   e. Schoology

9. Which one of the internet applications mentioned below is included the example of virtual class .....
   a. Facebook
   b. Instagram
   c. Twitter
   d. Edmodo
   e. Flickr

10. One of the purposes of e-learning is a complement of conventional learning. The meaning of complement in the statement is .....
    a. As an enrichment of learning process
    b. As a replacement of the whole learning process
    c. As a replacement of some section in the conventional learning process
    d. As a learning strategic
    e. As a learning method

11. Which one the right order of the production process for multimedia products .....
    a. production -> pre-production -> post-production
    b. pre-production -> production -> post-production
    c. pre-production -> post-production -> production
    d. production -> post-production -> pre-production
    e. post-production -> pre-production -> production

12. What is the definition of video pre-production .....
    a. The process of distributing a final video to the user
    b. The process of labeling and making a cover for CD/DVD
    c. The finishing stage of a series which includes editing images, structuring titles, graphics, animation, and special effects, music, sound effects, audio dubbing
    d. The taking video process which refers to the preparation produced from the pre-production
    e. The initial stage of collecting all data and elements related to production

13. Below is part of the video pre-production process, except .....
    a. Making Synopsis
    b. Making Script
    c. Making Storyboard
    d. Preparing editing video equipment
    e. Search for idea and concept

14. The definition of the synopsis is .....
    a. The storyline which is explained in brief
    b. Everything related to data and information on the production process from the beginning until the end
    c. A text that contains an overview that will be displayed on the screen
    d. A description of what is needed in the production
    e. A thumbnail which arranged sequentially in accordance with the storyline

15. The following are the steps in determining the concept or idea in the pre-production process, except .....
    a. Determining the title
    b. Determining the targeted audiences
    c. Determining the work plan
    d. Specifying the pictures want to display
    e. Determining the style want to perform

16. The definition of the script is .....
    a. The storyline which is explained in brief
    b. Everything related to data and information on the production process from the beginning until the end
    c. A text that contains an overview that will be displayed on the screen
    d. A description of what is needed in the production
    e. A thumbnail which arranged sequentially in accordance with the storyline

17. Based on the existing script, it is necessary to conduct a study covering the following aspects, except .....
    a. The number and character of the actor
    b. The number and type of environment
    c. The number and character of the audience
    d. The number and type of property, wardrobe, and object product
    e. The equipment needed

18. The following are included in the type of script, except .....
    a. Non-story
    b. News
    c. Story
    d. Public Service Advertisement
    e. Production

19. The definition of the storyboard is .....
    a. The storyline which is explained in brief
    b. Everything related to data and information on the production process from the beginning until the end
    c. A text that contains an overview that will be displayed on the screen
    d. A description of what is needed in the production
    e. A thumbnail which arranged sequentially in accordance with the storyline

20. A storyboard is usually formed in the form of thumbnails arranged vertically or horizontally. In addition, it is also equipped with information guides that are useful in the process of shooting. How to order the correct thumbnails in order to be able to describe the storyline in making a storyboard .....
    a. Starting from the top-right side and ending at the bottom-right side
    b. Starting from the top-right side and ending at the bottom-left side
    c. Starting from the top-left side and ending at the bottom-right side
    d. Starting from the top-left side and ending at the bottom-left side
    e. Starting from the top-middle side and ending at the bottom-middle side

21. The main equipment that must be prepared when recording video is .....
    a. Microphone
    b. Lamp
    c. Handycam
    d. Handphone
    e. Headset

22. The standard equipment used by the cameraman to make the shooting more stable is .....
    a. Fish eye
    b. Camera lamp
    c. Camera
    d. Microphone
    e. Tripod

23. To adjust the camera sensitivity to the light .....
    a. fluorescent
    b. daylight
    c. blue balance
    d. white balance
    e. dark balance

24. To set indoor lighting, how high K ideally use for the lamp .....
    a. 3.000 K
    b. 3.200 K
    c. 3.700 K
    d. 4.000 K
    e. 4.500 K

25. The symbol (icon) for setting auto white balance on the camera is .....
    a. sun
    b. lamp
    c. AWB
    d. Flash
    e. cloudy

26. How many seconds the minimal scene should take in order to make the video editor easier to edit the video .....
    a. 3 seconds
    b. 5 seconds
    c. 10 seconds
    d. 15 seconds
    e. 20 seconds

27. Another video which is taken while recording an object to provide additional explanations at the interview is called .....
    a. cutaway
    b. brackaway
    c. acting
    d. lighting
    e. mixing

28. The process of actors selection based on the character specified is called .....
    a. acting
    b. dubbing
    c. casting
    d. cutting
    e. dollying

29. How is taking a picture using the Knee Shot technique!
    a. Take a picture from a long position
    b. Take a full picture from head to foot
    c. Take a picture from a reasonable angle
    d. Take a picture from head to knee
    e. Take a picture by including all background

30. The camera movement will produce a different video. The procedure to take a video with the panning technique is .....
    a. Move the camera horizontally from left to right or right to left
    b. Move the camera horizontally from bottom to up
    c. Move the camera approaching the objects
    d. Move the camera avoiding the objects
    e. Move the camera freely

APPENDIX G:

THE ACHIEVEMENT TEST (INDONESIAN VERSION)

Tes Kemampuan

Mata Pelajaran : Simulasi dan Komunikasi Digital
Kelas : X TKJ
Semester : Genap
Waktu : 45 menit

Nama Lengkap : .....

NIS : .....

Kelas : .....

Waktu : a. Mulai mengerjakan ..... (tuliskan jam dan menit)

b. Selesai mengerjakan ..... (tuliskan jam dan menit)

Petunjuk:

Pilihlah salah satu jawaban yang benar dengan memberikan tanda silang (x) pada salah satu pilihan jawaban!

1. Di antara pilihan jawaban berikut, mana yang lebih tepat menggambarkan maksud dari kelas maya?
   a. Kelas yang diadakan tanpa tatap muka secara langsung antara guru dengan murid
   b. Kelas yang diperuntukkan bagi siswa yang belajarnya dipercepat sesuai dengan tingkat pemahaman materi
   c. Jangkauan atau jarak antar kelas yang satu dengan kelas yang lain secara berurutan
   d. Kelas yang dapat bertatap muka tanpa harus menggunakan jaringan internet
   e. Kelas dimana siswa tidak menggunakan perangkat keras sebagai media

2. Berikut ini termasuk potensi kunci dari pemanfaatan teknologi informasi dan komunikasi (TIK) dalam rangka revolusi pembelajaran, kecuali .....
   a. Konektivitas
   b. Fleksibilitas
   c. Interaksi
   d. Kolaborasi
   e. Limitation

3. Istilah kelas virtual atau kelas maya sudah cukup dipahami oleh banyak orang, ini merupakan salah satu bentuk penerapan dari teknologi informasi di bidang .....
   a. Sosial dan budaya
   b. Sosial media
   c. Pendidikan
   d. Teknik komputer
   e. Politik

4. Beberapa ahli mempunyai pemahaman yang hampir sama tentang definisi dari e-learning. Di antara pilihan jawaban berikut, mana yang bisa menggambarkan definisi e-learning yang paling sesuai .....
   a. Pembelajaran dengan memanfaatkan media konvensional
   b. Pembelajaran dengan memanfaatkan media buku
   c. Pembelajaran dengan memanfaatkan teknologi tepat guna
   d. Pembelajaran dengan memanfaatkan teknologi tinggi
   e. Pembelajaran dengan memanfaatkan teknologi informasi dan komunikasi

5. Berikut ini adalah model-model pembelajaran e-learning menurut Rashty (1999), kecuali .....
   a. Model Adjunct
   b. Model Konvensional
   c. Model Mixed
   d. Model Fully Online
   e. Model Blended

6. Bila di dalam sebuah pembelajaran ingin dilakukan secara e-learning, maka terdapat beberapa perangkat dan material yang dibutuhkan agar aplikasi pembelajaran e-learning tersebut dapat berjalan dengan baik. Di antara jawaban berikut, yang bukan termasuk komponen pendukung yang diperlukan dalam pembelajaran e-learning adalah .....
   a. Perangkat keras (*hardware*)
   b. Perangkat lunak (*software*)
   c. Perangkat bebas (*freeware*)
   d. Perangkat jaringan komputer
   e. Konten pembelajaran

7. Terdapat berbagai macam istilah yang digunakan dalam aplikasi kelas maya. Berikut ini adalah jenis-jenis yang termasuk dalam kelas maya, kecuali .....
   a. Learning Management System (LMS)
   b. Learning Content Management System
   c. Social Learning Network (SLN)
   d. Sosial Media (Sosmed)
   e. Computer Supported Social Learning (CSSL)

8. Di antara pilihan jawaban berikut, yang bukan termasuk dalam contoh dari Social Learning Network (SLN) adalah .....
   a. Network
   b. Einztein
   c. Sophia
   d. RemixLearning
   e. Schoology

9. Aplikasi internet yang disebutkan di bawah ini yang termasuk contoh dari kelas maya adalah .....
   a. Facebook
   b. Instagram
   c. Twitter
   d. Edmodo
   e. Flickr

10. Salah satu fungsi e-learning adalah sebagai complement dari pembelajaran konvensional. Arti dari complement pada pernyataan tersebut adalah .....
    a. Sebagai pengayaan pembelajaran
    b. Sebagai pengganti seluruh pembelajaran konvensional
    c. Sebagai pengganti sebagian pembelajaran konvensional
    d. Sebagai strategi pembelajaran
    e. Sebagai metode pembelajaran

11. Yang merupakan alir proses produksi produk multimedia adalah .....
    a. production -> pre-production -> post-production
    b. pre-production -> production -> post-production
    c. pre-production -> post-production -> production
    d. production -> post-production -> pre-production
    e. post-production -> pre-production -> production

12. Yang merupakan pengertian dari pra-produksi video adalah .....
    a. Proses distribusi video yang sudah jadi ke khalayak yang membutuhkan
    b. Proses pemberian label pada kepingan CD/DVD, dan pembuatan cover CD/DVD tersebut
    c. Tahap pemyelesain akhir (finishing) dari sebuah rangkaian yang meliputi pengeditan gambar, penataan title, grafik, animasi, dan special effect, music, sound effect, audio dubbing
    d. Tahap eksekusi lapang berupa syuting, yang mengacu pada persiapan yang dihasilkan dari proses pra-produksi
    e. Tahap awal pengumpulan semua data dan elemen yang berkaitan dengan produksi

13. Di bawah ini bagian dari proses pra-produksi video, kecuali .....
    a. Pembuatan Sinopsis
    b. Pembuatan Naskah
    c. Pembuatan Storyboard
    d. Persiapan perangkat editing video
    e. Pencarian ide dan konsep

14. Pengertian dari Sinopsis adalah .....
    a. Alur cerita yang dijelaskan dalam tulisan singkat
    b. Hal-hal yang berhubungan dengan data dan informasi keseluruhan produksi dari awal hingga akhir produksi
    c. Suatu teks yang berisi gambaran tentang apa yang akan terlihat di layar
    d. Penjabaran tentang kebutuhan yang diperlukan dalam produksi
    e. Sketsa gambar berbentuk thumbnail yang disusun berurutan sesuai dengan rangkaian jalan cerita

15. Berikut adalah langkah-langkah dalam penentuan konsep atau ide pada proses pra-produksi, kecuali .....
    a. Menentukan judul
    b. Menentukan target audience
    c. Menentukan rencana kerja
    d. Menentukan gambar yang akan ditampilkan
    e. Menentukan gaya yang ingin ditampilkan

16. Yang dimaksud dengan Naskah adalah .....
    a. Alur cerita yang dijelaskan dalam tulisan singkat
    b. Hal-hal yang berhubungan dengan data dan informasi keseluruhan produksi dari awal hingga akhir produksi
    c. Suatu teks yang berisi gambaran tentang apa yang akan terlihat di layar
    d. Penjabaran tentang kebutuhan yang diperlukan dalam produksi
    e. Sketsa gambar berbentuk thumbnail yang disusun berurutan sesuai dengan rangkaian jalan cerita

17. Berdasar naskah yang sudah ada perlu dilakukan kajian yang meliputi beberapa aspek berikut ini, kecuali .....
    a. Jumlah dan sifat karakter aktor
    b. Jumlah dan jenis lingkungan (setting/*environment*)
    c. Jumlah dan karakter target *audience*
    d. Jumlah dan jenis properti, wardrobe, dan objek produk
    e. Peralatan yang diperlukan

18. Berikut ini adalah yang termasuk dalam jenis naskah, kecuali .....
    a. Non-cerita
    b. Berita
    c. Cerita
    d. Iklan Layanan Masyarakat
    e. Produksi

19. Yang merupakan pengertian dari storyboard adalah .....
    a. Alur cerita yang dijelaskan dalam tulisan singkat
    b. Hal-hal yang berhubungan dengan data dan informasi keseluruhan produksi dari awal hingga akhir produksi
    c. Suatu teks yang berisi gambaran tentang apa yang akan terlihat di layar
    d. Penjabaran tentang kebutuhan yang diperlukan dalam produksi
    e. Sketsa gambar berbentuk thumbnail yang disusun berurutan sesuai dengan rangkaian jalan cerita

20. Storyboard biasanya dibentuk berupa panel gambar yang disusun secara vertikal ataupun horisontal. Selain itu juga dilengkapi dengan panduan informasi yang berguna dalam proses pengambilan gambar. Bagaimana urutan panel gambar yang benar untuk dapat menggambarkan alur cerita dalam membuat storyboard .....
    a. Dimulai dari sisi atas-kanan dan diakhiri di sisi bawah-kanan
    b. Dimulai dari sisi atas-kanan dan diakhiri di sisi bawah-kiri
    c. Dimulai dari sisi atas-kiri dan diakhiri di sisi bawah-kanan
    d. Dimulai dari sisi atas-kiri dan diakhiri di sisi bawah-kiri
    e. Dimulai dari sisi atas-tengah dan diakhiri di sisi bawah-tengah

21. Peralatan utama yang harus disiapkan pada saat merekam gambar adalah .....
    a. Mikrofon
    b. Lampu
    c. Handycam
    d. Handphone
    e. Headset

22. Peralatan standar yang digunakan oleh kamerawan agar pengambilan gambar lebih stabil adalah .....
    a. Fish eye
    b. Lampu kamera
    c. Kamera
    d. Mikrofon
    e. Tripod

23. Pada kamera untuk menyesuaikan tingkat kepekaan kamera terhadap instensitas cahaya, perlu pengaturan .....
    a. fluorescent
    b. daylight
    c. blue balance
    d. white balance
    e. dark balance

24. Dalam pengaturan cahaya, penerangan dalam ruangan idealnya menggunakan lampu dengan ukuran .....
    a. 3.000 K
    b. 3.200 K
    c. 3.700 K
    d. 4.000 K
    e. 4.500 K

25. Pengaturan cahaya pada kamera secara otomatis (auto white balance) memiliki simbol (ikon) .....
    a. matahari
    b. lampu
    c. AWB
    d. Flash
    e. cloudy

26. Untuk memudahkan editor mengambil potongan gambar, setiap adegan minimal direkam selama .....
    a. 3 detik
    b. 5 detik
    c. 10 detik
    d. 15 detik
    e. 20 detik

27. Sebuah rekaman lain yang diambil saat merekam sebuah objek untuk memberikan penjelasan tambahan pada saat wawancara adalah .....
    a. cutaway
    b. brackaway
    c. acting
    d. lighting
    e. mixing

28. Proses pemilihan pemain sesuai dengan karakter dan peran yang diberikan disebut .....
    a. acting
    b. dubbing
    c. casting
    d. cutting
    e. dollying

29. Bagaimana cara yang dilakukan untuk mengambil gambar dengan menggunakan teknik Knee Shot!
    a. Ambil gambar dari jarak yang jauh
    b. Ambil gambar secara penuh dari kepala sampai kaki
    c. Ambil gambar dari sudut yang wajar
    d. Ambil gambar objek dari kepala sampai lutut
    e. Ambil gambar dengan memasukkan keadaan sekeliling

30. Gerakan kamera akan menghasilkan gambar yang berbeda. Untuk melakukan pengambilan gambar dengan teknik panning, maka langkah-langkah yang dilakukan adalah .....
    a. Gerakkan kamera secara horizontal dari kiri ke kanan atau dari kanan ke kiri
    b. Gerakkan kamera secara vertikal dari bawah ke atas
    c. Gerakkan kamera mendekati objek
    d. Gerakkan kamera menjauhi objek
    e. Gerakkan kamera secara bebas

APPENDIX H:

LETTERS OF APPROVAL

PEMERINTAH DAERAH DAERAH ISTIMEWA YOGYAKARTA
BADAN KESATUAN BANGSA DAN POLITIK
Jl. Jenderal Sudirman No 5 Yogyakarta – 55233
Telepon : (0274) 551136, 551275, Fax (0274) 551137

Yogyakarta, 1 Februari 2018

Kepada Yth. :

Nomor : 074/1192/Kesbangpol/2018
Perihal : Rekomendasi Penelitian

Kepala Dinas Pendidikan, Pemuda, dan Olahraga DIY

di Yogyakarta

Memperhatikan surat :

Dari : Dekan Fakultas Teknik Universitas Negeri Yogyakarta
Nomor : 30/UN34.15/ELKO/LL/2018
Tanggal : 31 Januari 2018
Perihal : Permohonan Izin Penelitian

Setelah mempelajari surat permohonan dan proposal yang diajukan, maka dapat diberikan surat rekomendasi tidak keberatan untuk melaksanakan riset/penelitian dalam rangka penelitian dosen dengan judul proposal: ***"AN ADAPTIVE E-LEARNING SYSTEM BASED ON STUDENT'S LEARNING STYLES AND KNOWLEDGE LEVEL"*** kepada:

Nama : DIDIK HARIYANTO
NIP : 197705022003121001
No.HP/Identitas : 08170413587/3578060205770006
Prodi/Jurusan : Pendidikan Teknik Elektro
Fakultas : Fakultas Teknik Universitas Negeri Yogyakarta
Lokasi Penelitian : SMK Negeri 2 Pengasih, Kulon Progo
Waktu Penelitian : 1 Februari 2018 s.d 30 April 2018

Sehubungan dengan maksud tersebut, diharapkan agar pihak yang terkait dapat memberikan bantuan / fasilitas yang dibutuhkan.

Kepada yang bersangkutan diwajibkan:

1. Menghormati dan mentaati peraturan dan tata tertib yang berlaku di wilayah riset/penelitian;
2. Tidak dibenarkan melakukan riset/penelitian yang tidak sesuai atau tidak ada kaitannya dengan judul riset/penelitian dimaksud;
3. Menyerahkan hasil riset/penelitian kepada Badan Kesbangpol DIY selambat-lambatnya 6 bulan setelah penelitian dilaksanakan.
4. Surat rekomendasi ini dapat diperpanjang maksimal 2 (dua) kali dengan menunjukkan surat rekomendasi sebelumnya, paling lambat 7 (tujuh) hari kerja sebelum berakhirnya surat rekomendasi ini.

Rekomendasi Ijin Riset/Penelitian ini dinyatakan tidak berlaku, apabila ternyata pemegang tidak mentaati ketentuan tersebut di atas.

Demikian untuk menjadikan maklum.

KEPALA
BADAN KESBANGPOL DIY

AGUNG SUPRIYONO, SH
NIP. 19601026 199203 1 004

Tembusan disampaikan Kepada Yth :
1. Gubernur DIY (sebagai laporan)
2. Dekan Fakultas Teknik Universitas Negeri Yogyakarta;
3. Yang bersangkutan.

PEMERINTAH DAERAH DAERAH ISTIMEWA YOGYAKARTA
DINAS PENDIDIKAN, PEMUDA, DAN OLAHRAGA
Jalan Cendana No. 9 Yogyakarta, Telepon (0274) 541322, Fax. 541322
web : www.dikpora.jogjaprov.go.id, email : dikpora@jogjaprov.go.id, Kode Pos 55166

Yogyakarta, 2 Februari 2018

Nomor : 070/01241
Lamp : -
Hal : Rekomendasi Penelitian

Kepada Yth.
Kepala SMK N 2 Pengasih

Dengan hormat, memperhatikan surat dari Badan Kesatuan Bangsa dan Politik Pemerintah Daerah Daerah Istimewa Yogyakarta nomor: 074/1192/Kesbangpol/2018 tanggal 1 Februari 2018 perihal Rekomendasi Penelitian, kami sampaikan bahwa Dinas Pendidikan, Pemuda, dan Olahraga DIY memberikan ijin rekomendasi penelitian kepada :

Nama	: Didik Hariyanto
NIM	: 197705022003121001
Prodi/Jurusan	: Pendidikan Teknik Elektro
Fakultas	: Fakultas Teknik, Universitas Negeri Yogyakarta
Judul	: *AN ADAPTIVE E-LEARNING SYSTEM BASED IN STUDENT'S LEARNING STYLES AND KNOWLEDGE LEVEL*
Lokasi	: SMK Negeri 2 Pengasih, Kulon Progo
Waktu	: 1 Februari 2018 s.d 30 April 2018

Dengan ketentuan sebagai berikut :

1. Ijin ini hanya dipergunakan untuk keperluan ilmiah, dan pemegang ijin wajib mentaati ketentuan yang berlaku di lokasi penelitian.
2. Ijin yang diberikan dapat dibatalkan sewaktu-waktu apabila pemegang ijin ini tidak memenuhi ketentuan yang berlaku.

Atas perhatian dan kerjasama yang baik, kami menyampaikan terimakasih.

a.n Kepala
Plt. Kepala Bidang Perencanaan dan Standarisasi

PEMERINTAH DAERAH DAERAH ISTIMEWA YOGYAKARTA DISDIKPORA

Didik Wardaya, SE., M.Pd.
NIP 19660530 198602 1 002

Tembusan Yth :
1. Kepala Dinas Dikpora DIY
2. Kepala Bidang Dikmenti Dinas Dikpora DIY

F/4.2.3/KTU/2
1 Juli 2018
SMK N 2 Pengasih

PEMERINTAH DAERAH DAERAH ISTIMEWA YOGYAKARTA
DINAS PENDIDIKAN, PEMUDA DAN OLAH RAGA
SEKOLAH MENENGAH KEJURUAN NEGERI 2 PENGASIH
Jalan KRT, Kertodiningrat, Margosari Pengasih, Kulon Progo, Yogyakarta
Telpon (0274) 773029,Fax. (0274) 774289,773888, e-mail : smk2pengasih_kp@yahoo.com
homepage : www.smkn2pengasih.sch.id

TÜVRheinland CERTIFIED

SURAT KETERANGAN TELAH MELAKUKAN PENELITIAN

No. : 070.2 / 712

Yang bertanda tangan di bawah ini,

Nama	:	**SUMARNO, S.Pd., MT.**
NIP	:	19660510 198902 1 003
Pangkat / Gol	:	Pembina/ IVa
Jabatan	:	Kepala Sekolah
Unit Kerja	:	SMK Negeri 2 Pengasih

Menerangkan bahwa :

Nama	:	**DIDIK HARIYANTO**
NIP	:	197705022003121001
PT / Instansi	:	Pendidikan Teknik Elektro Fakultas Teknik Universitas Negeri Yogyakarta

Mahasiswa tersebut di atas telah melaksanakan penelitian di SMK N 2 Pengasih pada 01 Februari 2018 s/d 30 April 2018 dan 11 Maret 2019 s/d 05 April 2019 dengan Judul Penelitian :

"AN ADAPTIVE E-LEARNING SYSTEM BASED ON STUDENT'S LEARNING STYLE AND KNOWLEDGE LEVEL"

Surat keterangan ini diberikan untuk dipergunakan sebagaimana mestinya.

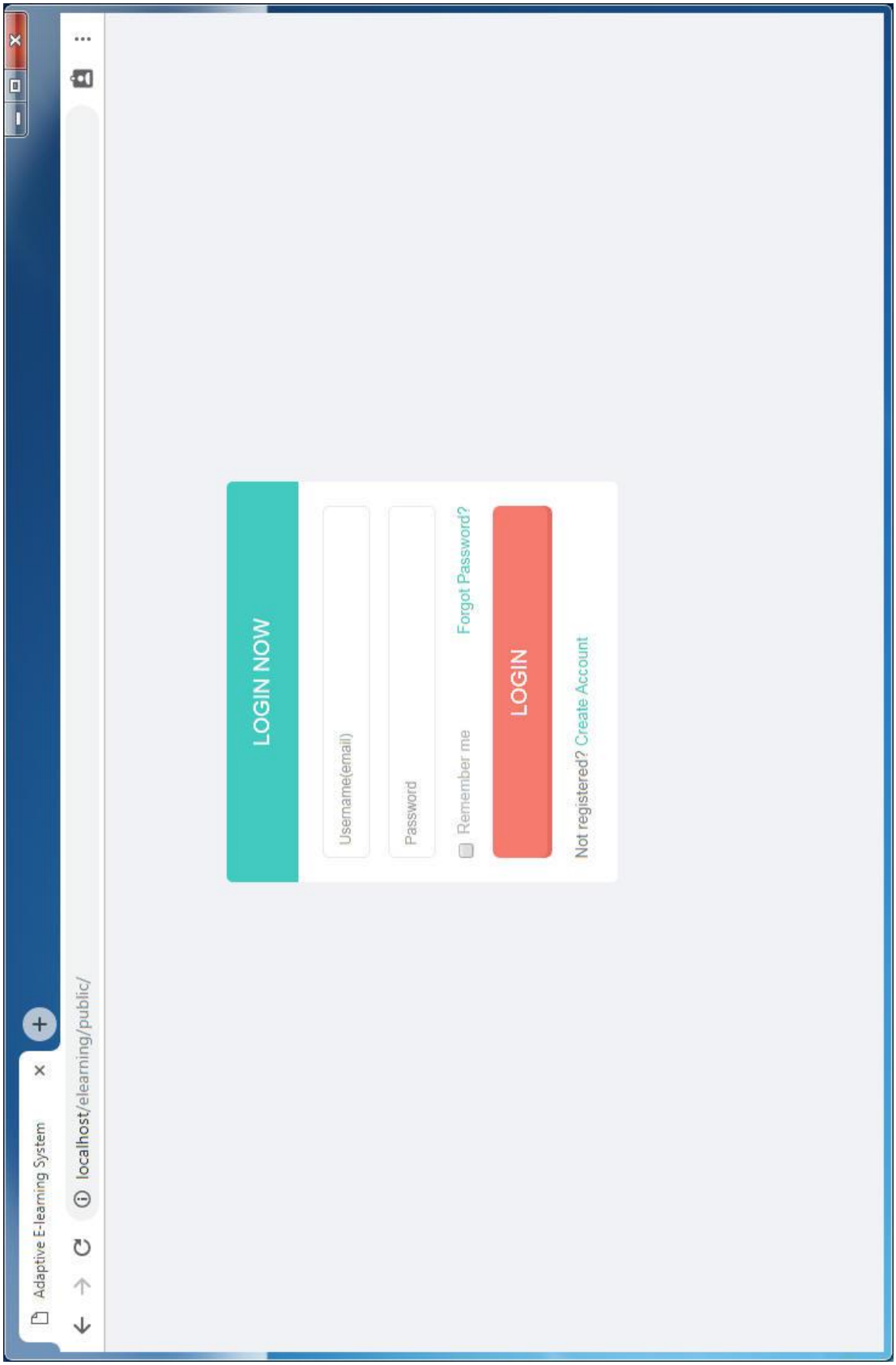
Di keluarkan di Kulon Progo
Pada tanggal 19 Juni 2019
Kepala SMK N 2 Pengasih

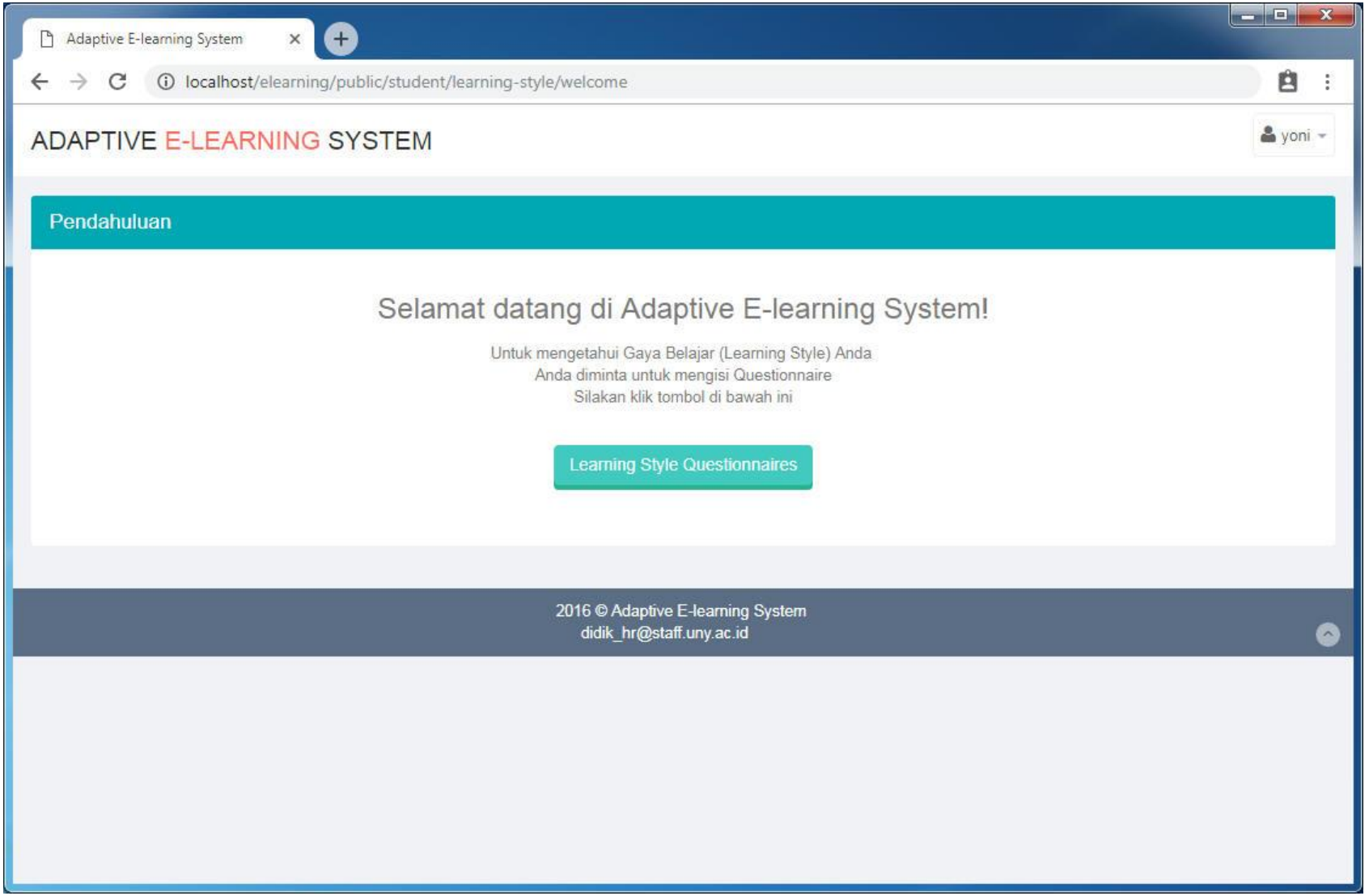
PEMERINTAH DAERAH DIY SMKN 2 PENGASIH DISDIKPORA

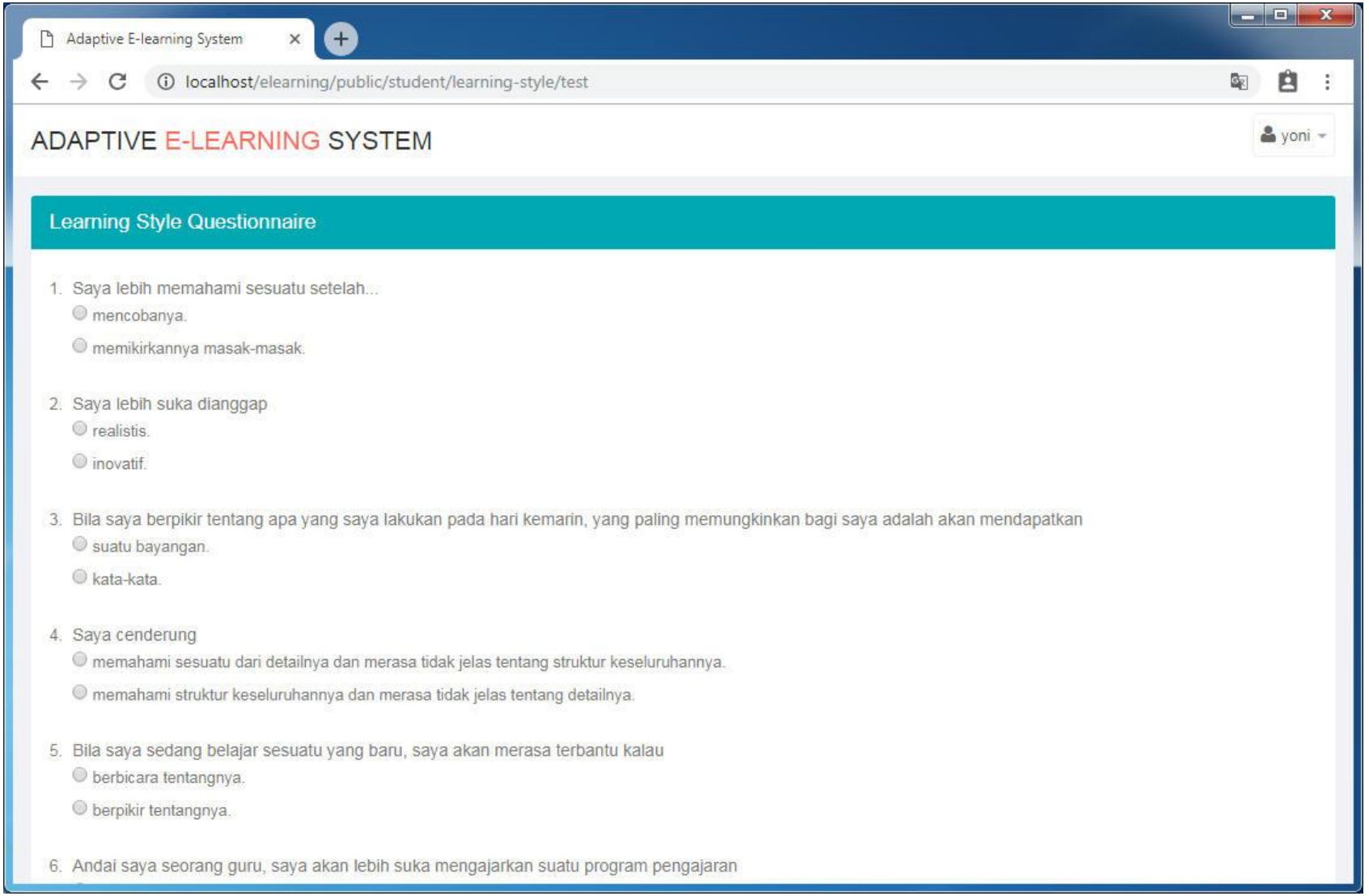
SUMARNO, S.Pd., M.T.
NIP. 19660510 198902 1 003

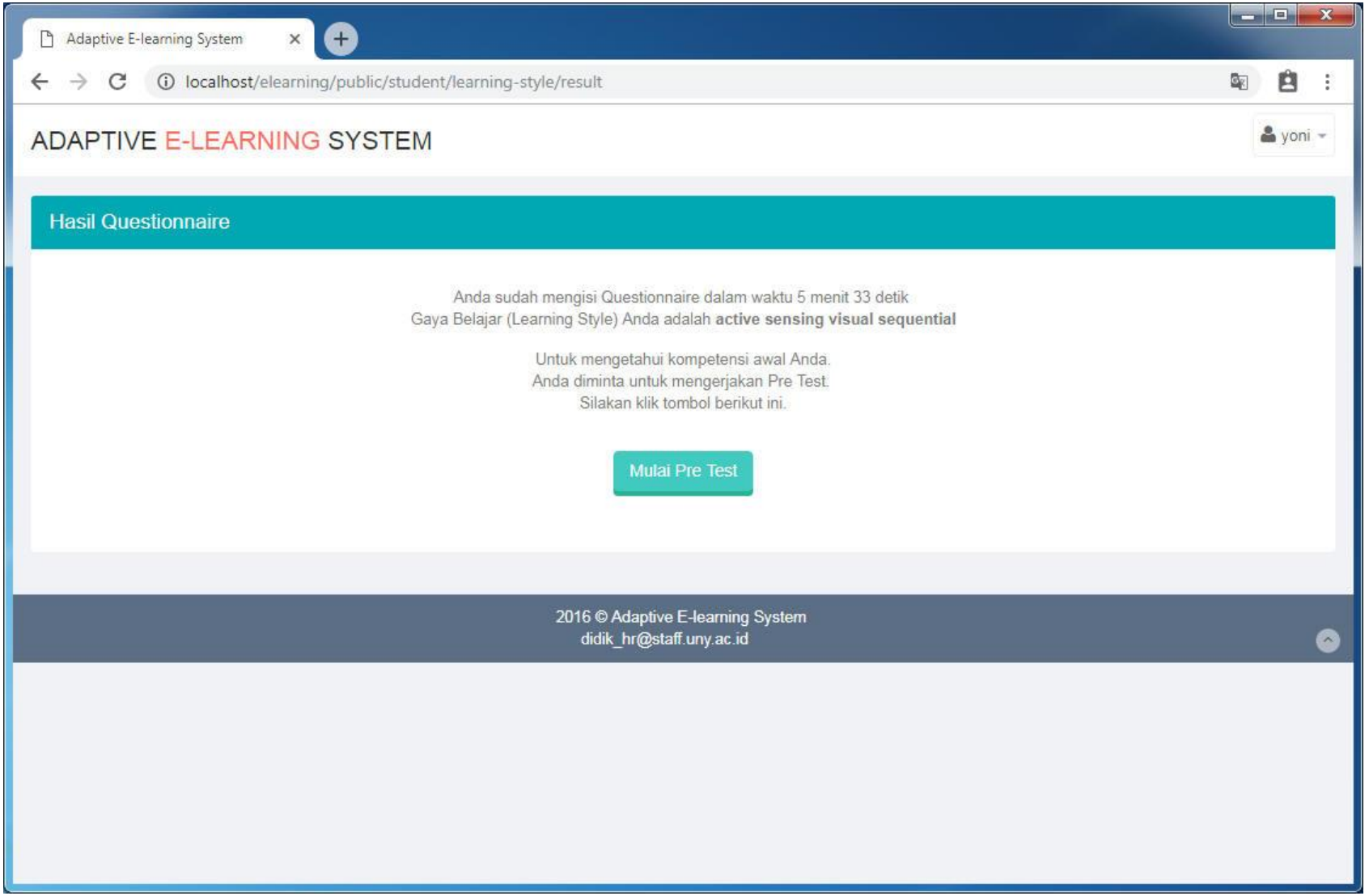
APPENDIX I:

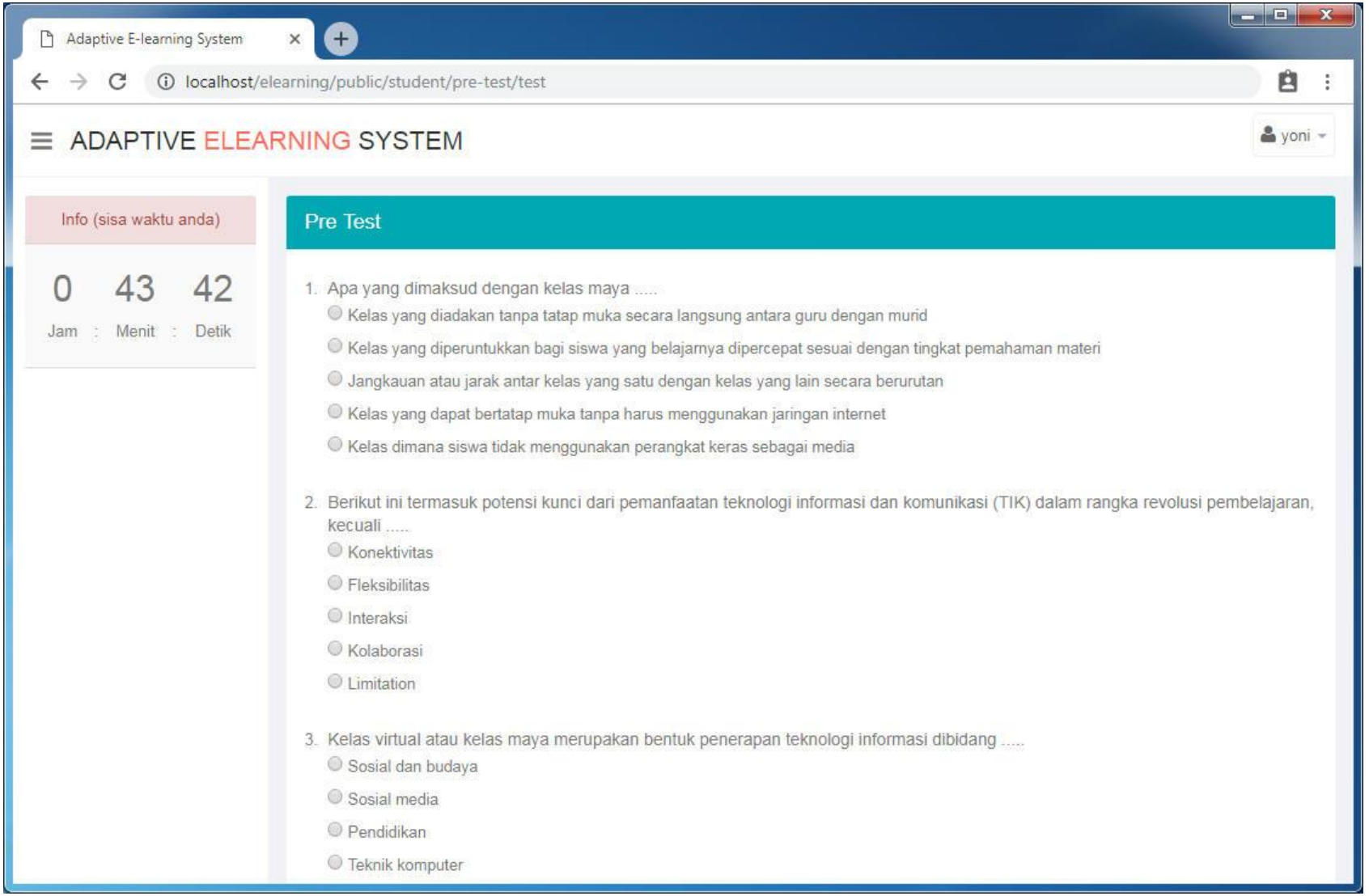
SOME SCREENSHOTS OF THE ADAPTIVE E-LEARNING SYSTEM

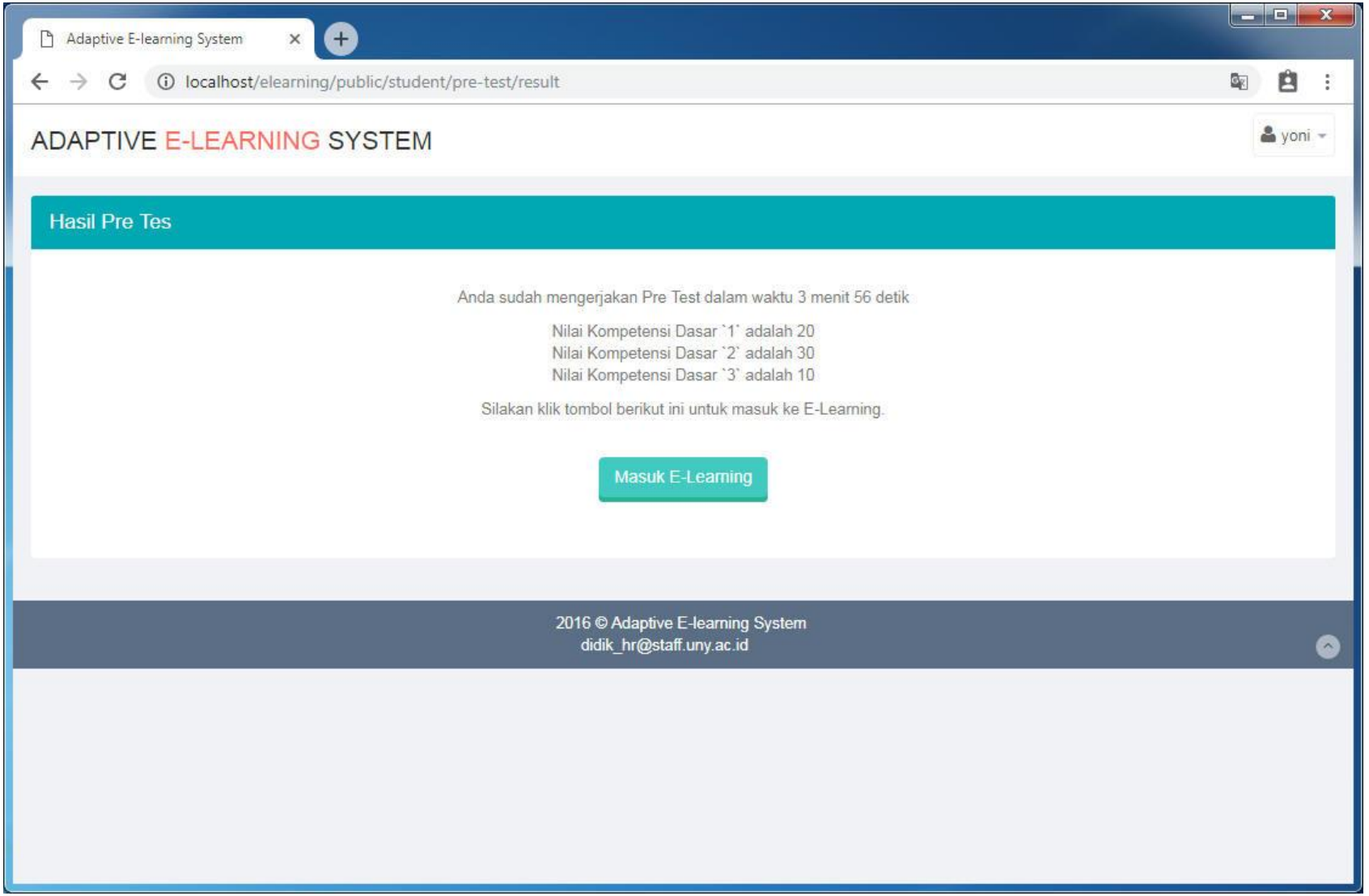


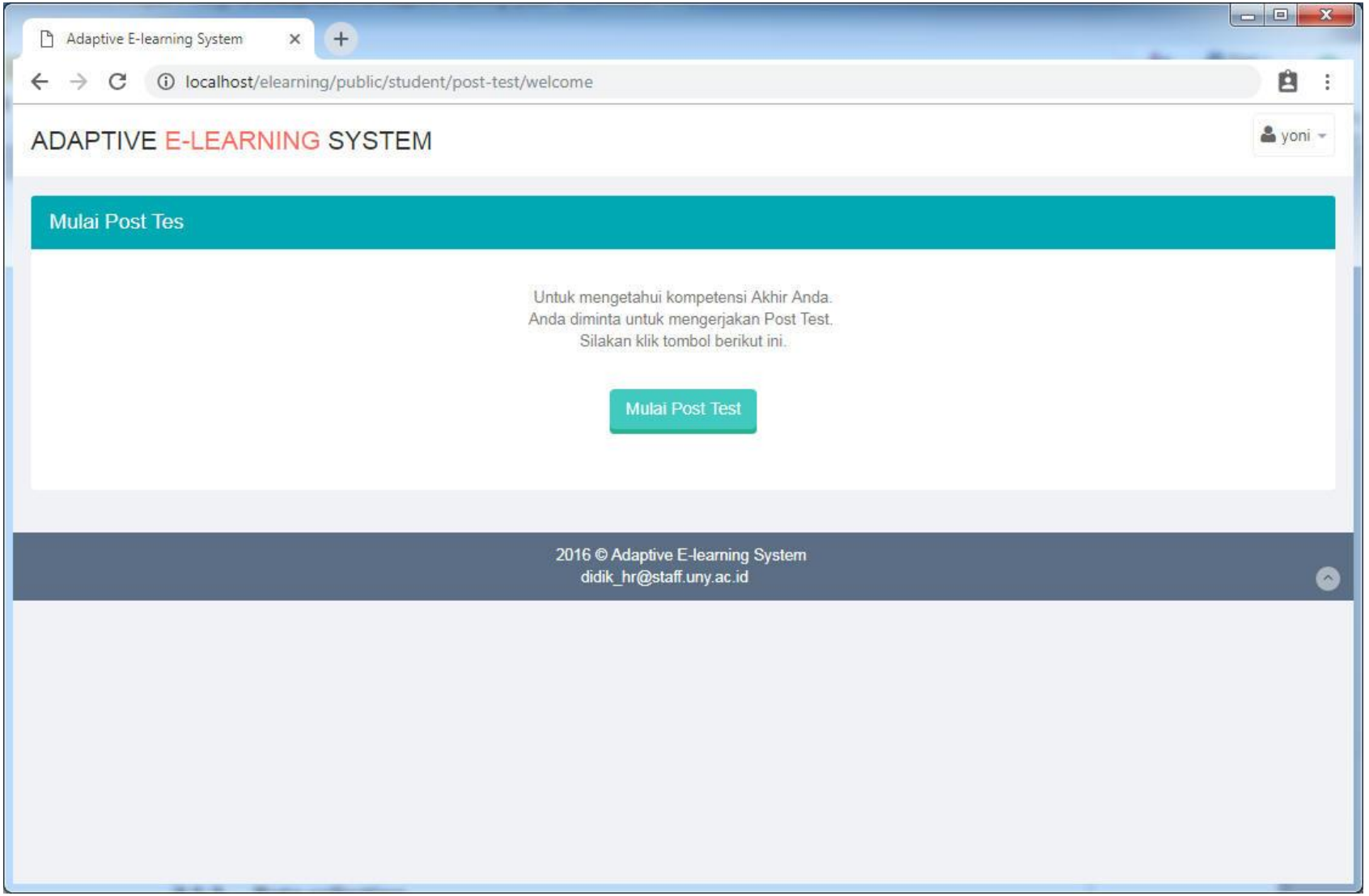

Adaptive E-learning System
localhost/elearning/public/student/learning-style/welcome
ADAPTIVE E-LEARNING SYSTEM
yoni
Pendahuluan
Selamat datang di Adaptive E-learning System!
Untuk mengetahui Gaya Belajar (Learning Style) Anda
Anda diminta untuk mengisi Questionnaire
Silakan klik tombol di bawah ini
Learning Style Questionnaires
2016 © Adaptive E-learning System
didik_hr@staff.uny.ac.id

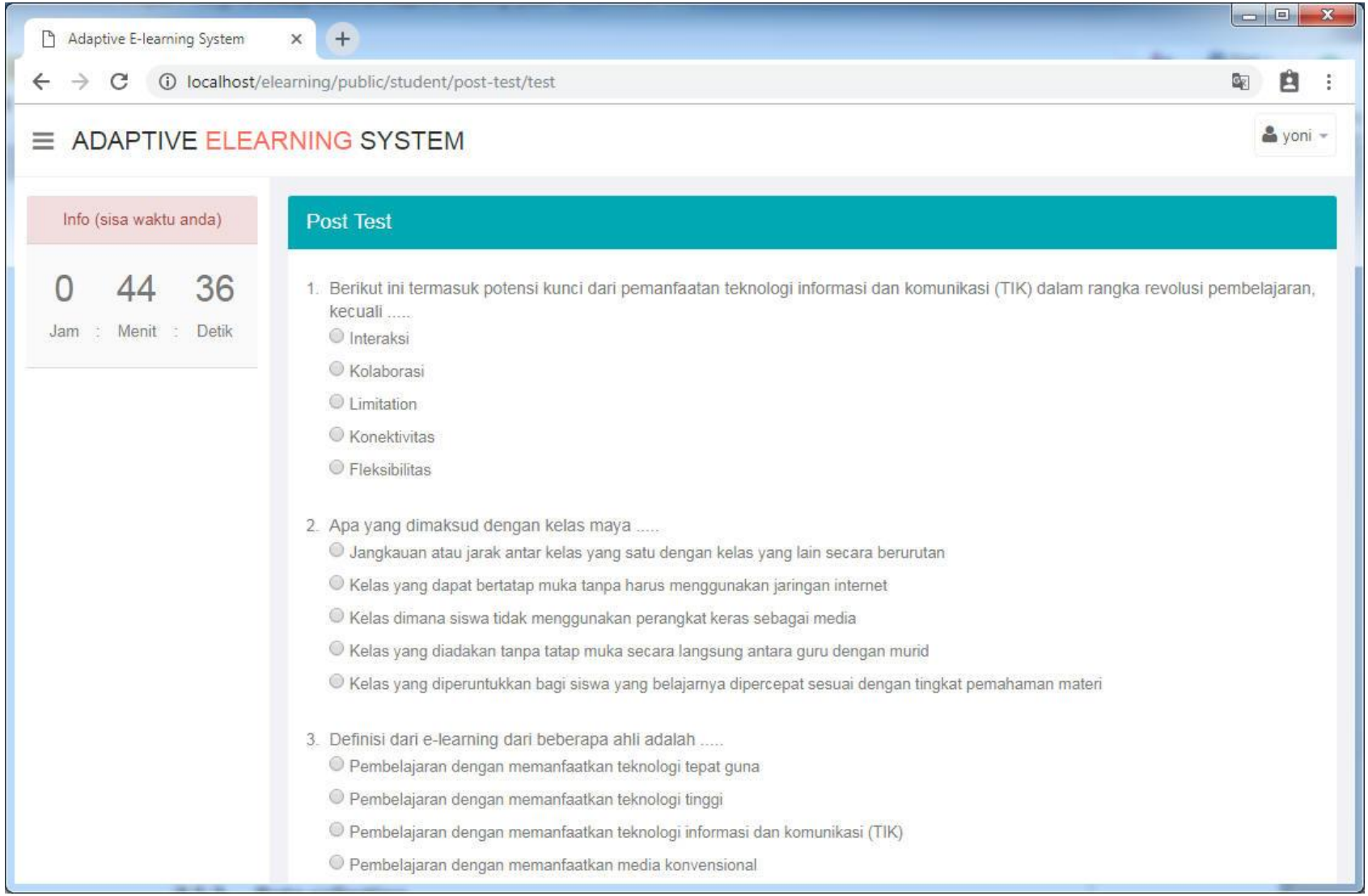

Adaptive E-learning System
localhost/elearning/public/student/learning-style/test
ADAPTIVE E-LEARNING SYSTEM
yoni
Learning Style Questionnaire
1. Saya lebih memahami sesuatu setelah...
mencobanya.
memikirkannya masak-masak.
2. Saya lebih suka dianggap
realistis.
inovatif.
3. Bila saya berpikir tentang apa yang saya lakukan pada hari kemarin, yang paling memungkinkan bagi saya adalah akan mendapatkan
suatu bayangan.
kata-kata.
4. Saya cenderung
memahami sesuatu dari detailnya dan merasa tidak jelas tentang struktur keseluruhannya.
memahami struktur keseluruhannya dan merasa tidak jelas tentang detailnya.
5. Bila saya sedang belajar sesuatu yang baru, saya akan merasa terbantu kalau
berbicara tentangnya.
berpikir tentangnya.
6. Andai saya seorang guru, saya akan lebih suka mengajarkan suatu program pengajaran

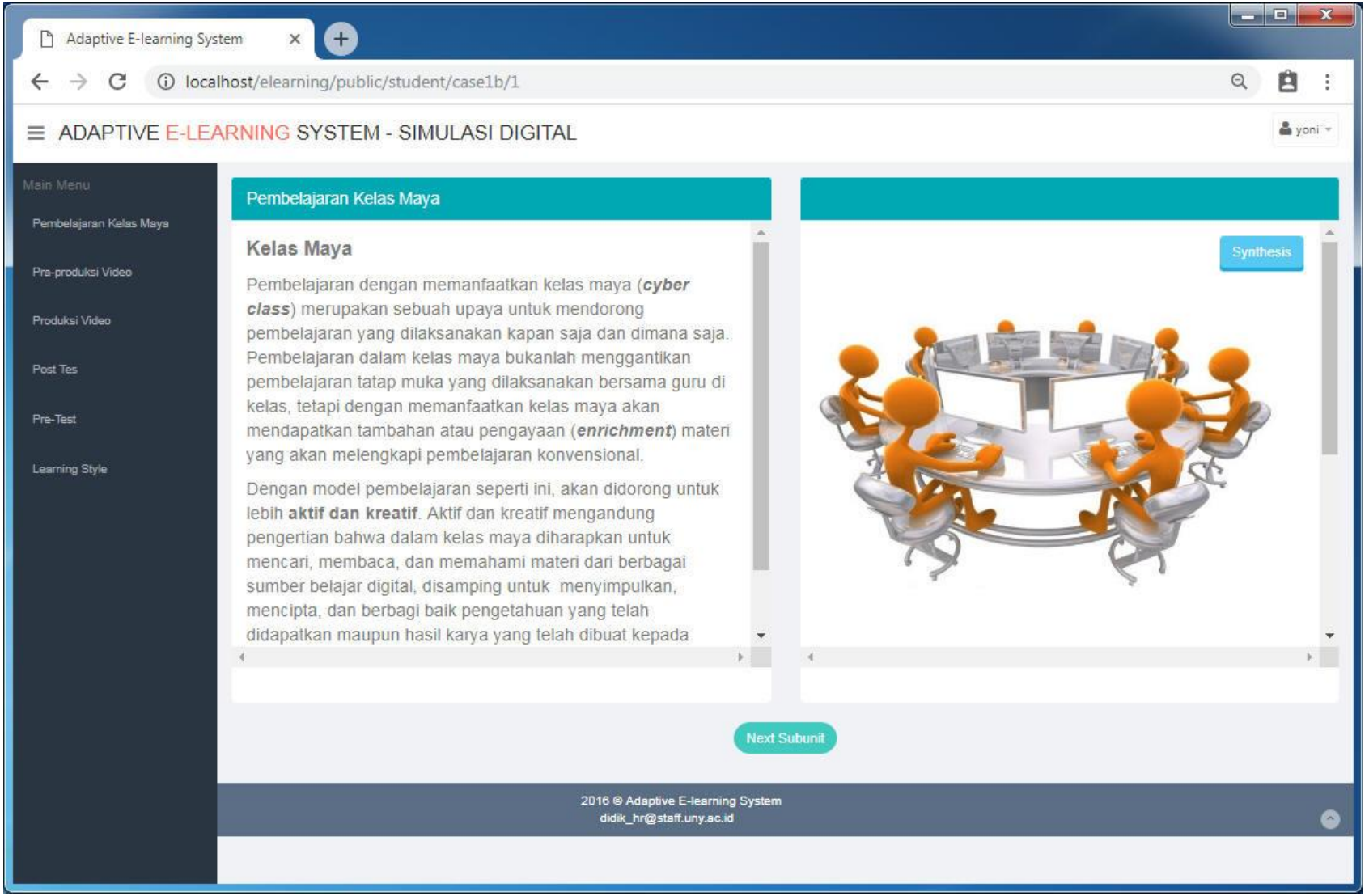

Adaptive E-learning System
localhost/elearning/public/student/learning-style/result
ADAPTIVE E-LEARNING SYSTEM
yoni
Hasil Questionnaire
Anda sudah mengisi Questionnaire dalam waktu 5 menit 33 detik
Gaya Belajar (Learning Style) Anda adalah active sensing visual sequential
Untuk mengetahui kompetensi awal Anda.
Anda diminta untuk mengerjakan Pre Test.
Silakan klik tombol berikut ini.
Mulai Pre Test
2016 © Adaptive E-learning System
didik_hr@staff.uny.ac.id


Adaptive E-learning System
localhost/elearning/public/student/pre-test/test
ADAPTIVE ELEARNING SYSTEM
yoni
Info (sisa waktu anda)
0 Jam : 43 Menit : 42 Detik
Pre Test
1. Apa yang dimaksud dengan kelas maya .....
Kelas yang diadakan tanpa tatap muka secara langsung antara guru dengan murid
Kelas yang diperuntukkan bagi siswa yang belajarnya dipercepat sesuai dengan tingkat pemahaman materi
Jangkauan atau jarak antar kelas yang satu dengan kelas yang lain secara berurutan
Kelas yang dapat bertatap muka tanpa harus menggunakan jaringan internet
Kelas dimana siswa tidak menggunakan perangkat keras sebagai media
2. Berikut ini termasuk potensi kunci dari pemanfaatan teknologi informasi dan komunikasi (TIK) dalam rangka revolusi pembelajaran, kecuali .....
Konektivitas
Fleksibilitas
Interaksi
Kolaborasi
Limitation
3. Kelas virtual atau kelas maya merupakan bentuk penerapan teknologi informasi dibidang .....
Sosial dan budaya
Sosial media
Pendidikan
Teknik komputer


Adaptive E-learning System
localhost/elearning/public/student/pre-test/result
ADAPTIVE E-LEARNING SYSTEM
yoni
Hasil Pre Tes
Anda sudah mengerjakan Pre Test dalam waktu 3 menit 56 detik
Nilai Kompetensi Dasar `1` adalah 20
Nilai Kompetensi Dasar `2` adalah 30
Nilai Kompetensi Dasar `3` adalah 10
Silakan klik tombol berikut ini untuk masuk ke E-Learning.
Masuk E-Learning
2016 © Adaptive E-learning System
didik_hr@staff.uny.ac.id


Adaptive E-learning System
localhost/elearning/public/student/post-test/welcome
ADAPTIVE E-LEARNING SYSTEM
yoni
Mulai Post Tes
Untuk mengetahui kompetensi Akhir Anda.
Anda diminta untuk mengerjakan Post Test.
Silakan klik tombol berikut ini.
Mulai Post Test
2016 © Adaptive E-learning System
didik_hr@staff.uny.ac.id


Adaptive E-learning System
localhost/elearning/public/student/post-test/test
ADAPTIVE ELEARNING SYSTEM
yoni
Info (sisa waktu anda)
0 Jam : 44 Menit : 36 Detik
Post Test
1. Berikut ini termasuk potensi kunci dari pemanfaatan teknologi informasi dan komunikasi (TIK) dalam rangka revolusi pembelajaran, kecuali .....
Interaksi
Kolaborasi
Limitation
Konektivitas
Fleksibilitas
2. Apa yang dimaksud dengan kelas maya .....
Jangkauan atau jarak antar kelas yang satu dengan kelas yang lain secara berurutan
Kelas yang dapat bertatap muka tanpa harus menggunakan jaringan internet
Kelas dimana siswa tidak menggunakan perangkat keras sebagai media
Kelas yang diadakan tanpa tatap muka secara langsung antara guru dengan murid
Kelas yang diperuntukkan bagi siswa yang belajarnya dipercepat sesuai dengan tingkat pemahaman materi
3. Definisi dari e-learning dari beberapa ahli adalah .....
Pembelajaran dengan memanfaatkan teknologi tepat guna
Pembelajaran dengan memanfaatkan teknologi tinggi
Pembelajaran dengan memanfaatkan teknologi informasi dan komunikasi (TIK)
Pembelajaran dengan memanfaatkan media konvensional


Adaptive E-learning System
localhost/elearning/public/student/case1b/1
ADAPTIVE E-LEARNING SYSTEM - SIMULASI DIGITAL
yoni
Main Menu
Pembelajaran Kelas Maya
Pra-produksi Video
Produksi Video
Post Tes
Pre-Test
Learning Style
Pembelajaran Kelas Maya
Kelas Maya
Pembelajaran dengan memanfaatkan kelas maya (cyber class) merupakan sebuah upaya untuk mendorong pembelajaran yang dilaksanakan kapan saja dan dimana saja. Pembelajaran dalam kelas maya bukanlah menggantikan pembelajaran tatap muka yang dilaksanakan bersama guru di kelas, tetapi dengan memanfaatkan kelas maya akan mendapatkan tambahan atau pengayaan (enrichment) materi yang akan melengkapi pembelajaran konvensional.
Dengan model pembelajaran seperti ini, akan didorong untuk lebih aktif dan kreatif. Aktif dan kreatif mengandung pengertian bahwa dalam kelas maya diharapkan untuk mencari, membaca, dan memahami materi dari berbagai sumber belajar digital, disamping untuk menyimpulkan, mencipta, dan berbagi baik pengetahuan yang telah didapatkan maupun hasil karya yang telah dibuat kepada
Synthesis
Next Subunit
2016 © Adaptive E-learning System
didik_hr@staff.uny.ac.id

STATEMENT OF AUTHORSHIP

I hereby declare that I have personally written the present doctoral thesis with the title **"An Adaptive E-Learning System based on Student's Learning Styles and Knowledge Level"** without any improper support of a third party and without using any other means than indicated. The help of third parties was only used in a scientifically appropriate way and within the permitted scope of examination regulations. There were no improper transfers of direct or indirect financial benefits in relation to the submitted doctoral thesis. The intellectual property which has been used directly or indirectly from other sources is clearly indicated. Up to this date, this doctoral thesis has never been published and has never been submitted in identical or similar form to any other examination board neither in Germany nor outside Germany.

Dresden, 11.11.2019

Didik Hariyanto