

# Development of Computer-Based Training to Supplement Lessons in Fundamentals of Electronics

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**Abstract** –Teaching Fundamentals of Electronics allow students to familiarize with basic electronics concepts, acquire skills in the use of multi-meter test instrument, and develop mastery in testing basic electronic components. Actual teaching and doing observations during practical activities on components pin identification and testing showed that the lack of skills of new students in testing components can lead to incorrect fault diagnosis and wrong pin connection during in-circuit replacement of the defective parts. With the aim of reinforcing students with concrete understanding of the concepts of components applied in the actual test and measurement, a Computer-Based Training was developed. The proponent developed the learning modules (courseware) utilizing concept mapping and storyboarding instructional design. Developing a courseware as simulated, activity-based and interactive as possible was the primary goal to resemble the real-world process. A Local area network (LAN)-based learning management system was also developed to use in administering the learning modules. The Paired Sample T-Test based on the pre-test and post-test result was used to determine whether the students achieved learning after taking the courseware. The result revealed that there is a significant achievement of the students after studying the learning module. The E-learning content was validated by the instructors in terms of contents, activities, assessment and format with a grand weighted mean of 4.35 interpreted as Sufficient. Based from the evaluation result, supplementing with the proposed computer-based training can enhance the teaching-learning process in electronic fundamentals.

**Keywords** – Computer-Based Training in Fundamentals of Electronics, Activity-Based E-learning, Concept Mapping, Courseware

## INTRODUCTION

As technology advances, it also improves the system, work flow and processes in organizations. The use of computers to develop software that will aid agencies in daily transactions is common. This is because the use of a well-designed computer programs improves daily business transactions of most private and government agencies, thus, improving productivity. The sector of education is one among those benefited by this technology advancement. With the design of new computers with high-speed capability which is capable of running multimedia, graphics, animation and simulation, coupled with the emergence of new instructional methodology, software developers find new ways and venture into development of software programs that can help in the enhancement of teaching-learning process. The first

computer-based training (CBT) software was information-based which was designed to supplement traditional classroom methodology. The delivery of the CBT can be desktop-based or web-based platform.

Eventually, new instructional methodology surfaced to augment the limitation of a purely content-based CBT. Some of these are activity-based, simulation, scenario-based and collaborative learning.

To promote E-learning and sound instructional design in educational sector in the Philippines, the government established agencies that will pioneer E-learning design and methodologies using the current multimedia technology. Dacanay[1] stated that the creation of Information Technology E-Commerce Council (ITECC) unifies all government and private sectors efforts in making the country electronically

enabled, and capable of participating and contributing to the global new economy.

The Republic Act No. 4883 also known as “Open Learning and Distance Education Acts” [2] aims to expand and democratize access to education at the post-secondary and tertiary level through open learning as philosophy to educational services, and the efficient and effective implementation of distance education as a system of delivering quality educational services in the country.

Pursuant to Section 2 B.P. 512 [3], the Camarines Sur Polytechnic Colleges shall provide higher technological, professional, and vocational instruction and training in fisheries, trades and technology, arts and sciences, as well as short term technical and vocational courses. The advocacy of the College to provide quality education driven the administrators to develop means for the enhancement of the curricula as signified by the approval of the Board Resolution No. 11-714 on the Guidelines in the Preparation, Development and Evaluation of Instructional Materials [4].

At Camarines Sur Polytechnic Colleges, there are two vocational courses offered in the College of Information and Communications Technology (CICT): Electronics Communications and Service Technology (ECST) and Computer Technician[5].The subject Fundamentals of Electronics is part of the curriculum of the said courses.The objectives of the aforementioned subject are to familiarize with basic electronics concepts and to develop mastery testing electronic components. These are pre-requisite skills in equipment troubleshooting and repair. One of the keys to a successful repair of most electronic equipment is through mastery of electronic components’ functions, its work in a particular circuit and its proper testing and measurement.

The course is aligned with the curriculum designed by Technical Education and Skills Development Authority (TESDA) for vocational educations, the contents of Fundamentals of Electronics is guided by Training Regulation (TR) in Consumer Electronics. This TR is designed to enhance the knowledge, skills and attitudes of a trainee/student on core competencies such as assemble/disassemble consumer electronic products and systems, maintain and repair audio/video products and systems, electronically-controlled domestic appliances and cellular phones in accordance with the industry standards [6]. Thus, ECST and CT students

have to undergo TESDA NC II Assessment that comprises the assessment of fundamentals skills such as electronics components tests, voltage measurement, power supply assembly and basic troubleshooting.

As one among the instructors in the College who handle this subject, there are difficulties encountered in the teaching-learning process. Difficulties were revealed through personal observation during laboratory activities and when evaluating projects that the students have performed.

Basic electronic components are most commonly used in basic electronics works. It is in working with these devices where beginners start to develop mastery in testing, measurement, maintenance and troubleshooting. During hands-on dealing with basic electronics devices such as identifying component pin-out and using multi-meter in testing, it was found out that many related test instrument and basic electronics components damage incidents are caused by improper voltage checking and measurement procedures. When practicing assembly and repair of low voltage power supply such as simple converter or DC battery, beginners tend to be confused of the procedures in voltage measurement and continuity checking using multi-meter. Many students have low performance on these basic electronics skills. In turn, this makes them very difficult to pass the National Certificate (NC) II Assessment.

In order for the students to satisfactorily accomplish assembly and troubleshooting and to have higher chance of passing the NC II assessment, they must have a solid foundation in safety, electronic components identification and testing, as well as DC voltage measurement using Multi-meter instrument.

With these concerns, the researcher was motivated to develop computer-based training software as a supplement on the student-learning process in Fundamentals of Electronics.

#### **OBJECTIVES OF THE STUDY**

The focal point of the study is the development of a Computer-Based Training in Fundamentals of Electronics to enhance and supplement the instructional methodology being utilized in teaching basic electronics. It aims to develop a computer-based training based on the identified skills that needs to be reinforced, to evaluate its effectiveness and to utilize it as a supplemental tool for the teaching methodology in fundamentals of electronics.

**MATERIALS AND METHODS**

**Respondents**

The respondents of the study were twenty (20) Freshmen Electronic Servicing students who were randomly selected and ten (10) instructors handling basic electronics subjects at Camarines Sur Polytechnic Colleges, five (5) instructors from Information Technology department and five (5) instructors from the College of Engineering (COE) department. A questionnaire was formulated and distributed to ten (10) instructors of Electronics for the validation of the courseware in terms of contents, activities, assessment and format.

To quantify the responses in the validation of the courseware, the 5-point Likert Rating Scale was utilized using the following descriptions:

Table 1. Five-point Likert Scale

Scale	Range-Value	Verbal Interpretation
5	4.50-5.00	Highly Sufficient
4	3.50-4.49	Sufficient
3	2.50-3.49	Moderately Sufficient
2	1.50-2.49	Fairly Sufficient
1	1.00-1.49	Not Sufficient

**Interview**

The researcher conducted interview with the respondents in order for him to gather pertinent information about the current methodology used in teaching basic electronics subjects, difficulties encountered therein and will solicit some recommendations to further enhance the teaching-learning process.

**Observation**

Done during hands-on time on the practical activities dealing with basic electronics devices such as identifying component pin-out and using multi-meter in component testing and DC voltage measurement was conducted by the proponent. Based on the observation during laboratory activities of students as well as interview conducted to instructors handling the subject, the Light Emitting Diode (LED) is the most commonly used electronics components in basic electronics works. The LED's function in the circuit is very important since it serves as indicator, display and troubleshooting tool among others. Unfortunately, it is also the most damaged device due to short-circuit and due to application of power and current that it is beyond its handling capability especially by a beginners. The LED has a very low wattage and voltage level. Wrong in-circuit

connection, over-voltage and electronic short can easily destroy this very essential device. So the proponent decided that the topics in LED voltage measurement, biasing, pin identification and proper in-circuit connection be included with worked example and practice.

**System Development Methodology**

The table 2 shows the hardware and software requirements in the development of the computer-based training. In terms of the computer used in the development of the computer-based training, dual core processors or higher was chosen since it is capable of efficiently processing programs. In animating the character and other elements of the computer-based training, flash was utilized. Moreover, .NET was installed in the operating system because most of the software used in the development of the system runs in this framework.

Table 2. Requirements for System Development

Hardware	Software
Intel Dual Core /AMD Athlon or higher	Windows XP SP3 or higher
CD/DVD drive	Adobe Flash CS3
2 GB RAM or higher	MS-Office
Monitor 1024 x 768 resolution or higher	Illustrator
Sound controller	Flash Player
Pen tablet	Photoshop
Network Controller	XAMPP
	MYSQL Workbench, XAMPP, MYSQL .NET CONNECTOR, .NET Framework

The development of the Computer-based Training utilized the Princeton Development Methodology. It is a development approach conceived by Princeton University that follows a route map for building client/server systems intended for use by multiple users or multiple departments [7]. This is composed of the following stages:

**Initiation.** Based on interviews, observations and the experience that the proponent had undertaken in teaching basic electronics subjects, difficulties were identified and topics that need to be developed into computer-based training were decided upon.

**Analysis.** The ideas and learning goals are gathered. The contents of the Computer-Based Training are taken into consideration and the target audience is identified and documented. It is in this

stage that the mode of delivery of the course is decided upon by the developers. The client/server software that will manage the learning modules and the students were analysed and the process flow of the entire system was decided upon by the proponent.

The E-learning is capable of managing courseware, managing test items, performing basic statistical functions and generating quiz results and grades. It has the feature of creating a set of modules to be studied by the students as well as recording teacher's information, student's information, module's information and other entities such as courses and subjects. The system was composed of two program modules: the Learning Management Module and the Student Module. The student module will allow students to answer the pre-test questions, study the learning modules, and then answer the post-test questions. The learning management module was used to create and manage courseware and tests, manages students, teachers, courses and subjects, performs database backup and restore, monitor quiz results and performs statistical analysis. The system runs on a local area network. The system's flow is shown in Figure 1.

The database server which stores all relevant information used in the computer-based training also runs the Teacher Module that will facilitate the learning of the students during the session. The teacher who will manage the learning modules must be logged-in before the student module can be used. The Student module which is connected to the database server consults the database for certain criteria and only displays learning modules and tests made active by the teacher using the Teacher module. When the student finishes the post-test, there will be an option to print the result of the test. The print output would be sent to any available printer that resides in the network. During the session, teacher can monitor the module completion of the students. When the student is done studying the courseware, the learning management module generates the needed reports.

**Design.** This stage presents the design of the proposed system. To define the relationship of the objects and to present the flow of the system in a systematic way, there are several modelling tools that were used by the researcher.

**Entity-Relationship Diagram**

This design stage illustrates the Entity-Relationship Diagram (ERD) of the proposed system.

ERD shows the relationships of entity sets in a database [8].The external entities that interact with the system are Teacher and Students. Figure 2 illustrates this relationship.

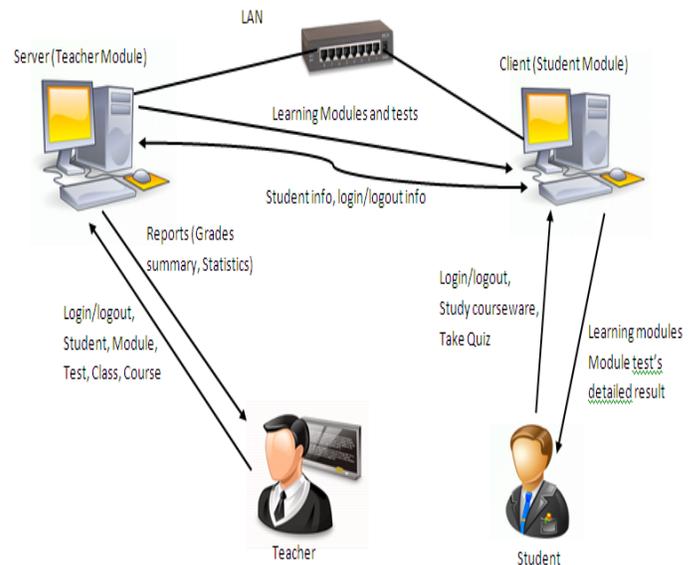


Figure 1. System Flow of the Computer-Based Training

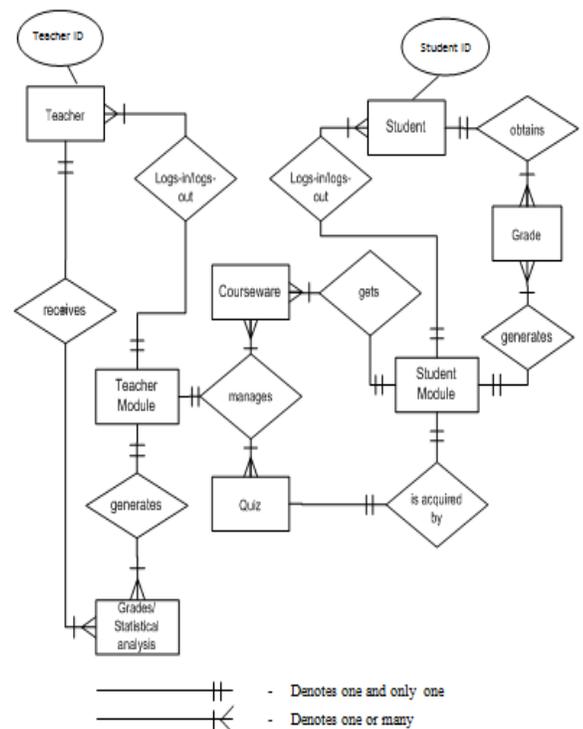


Figure 2. Entity-Relationship Diagram of the LMS

**Context Diagram**

The context diagram shows the overview of the system flow[9]. The external entities in which the system interacts with are teachers and students. The teacher login to the system, inputs student’s data or import it from an Excel file, course and subjects and prepares learning module and tests. After all essential information has been set by the teacher, the student logs in to the system. The activated courseware is studied and its corresponding tests are answered. The test result and grade is then fed back by the system to the student. Finally, the summary of test results and statistical reports are generated and viewed by the teacher. Figure 3 shows the context diagram of the system.

**Courseware Design**

**Concept Mapping.** Concept maps are useful tools for organizing and representing knowledge, critical thinking or planning. Concept and mind maps tend to be used more often for the initial stages in a learning sequence. A concept map explores several concepts. These concepts are enclosed in circles or boxes, and a connecting line between two or more concepts indicates relationships between concepts or propositions. Words on the connecting line can specify and describe the relationship between the two concepts [10]. The proponent utilized concept mapping in the initial task of the design of the learning modules. It enables him to have a general view of the main concepts and determine linkage of information and activities which must be present in the lesson. Figure 4 illustrates the concept map derived from the lesson Identifying LED Pins.

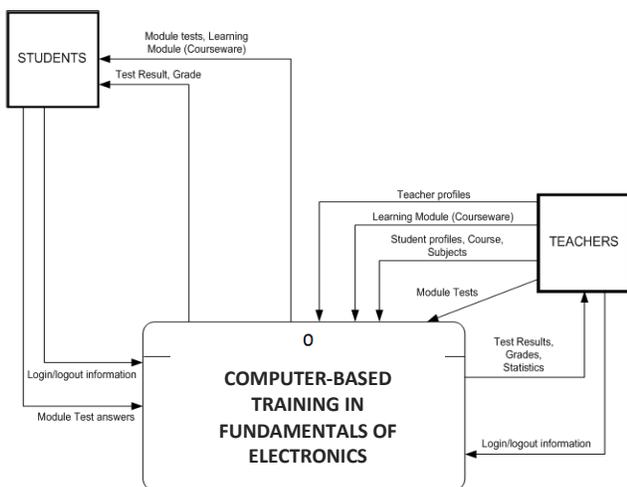


Figure 3. Context Diagram of the Proposed System

**Storyboarding.** To develop initial sketch of format, to organize the content and lesson flow or sequence, and to map the layout of the lessons before converting it into electronic format using Flash, the proponent made use of storyboard. A storyboard for E-Learning is a document that specifies the learning objectives, visual elements, text elements, audio elements, interactions and branching of every screen in a course [11].

**Development.** In this stage, the proponent will develop the solution decided upon during the previous phases. The software that will handle or manage the courseware and assessments is coded. The courseware content is converted into an electronic learning format. The multimedia assets are integrated and the learning objects are created for the course. Bugs were fixed and recommendations by the respondents were integrated.

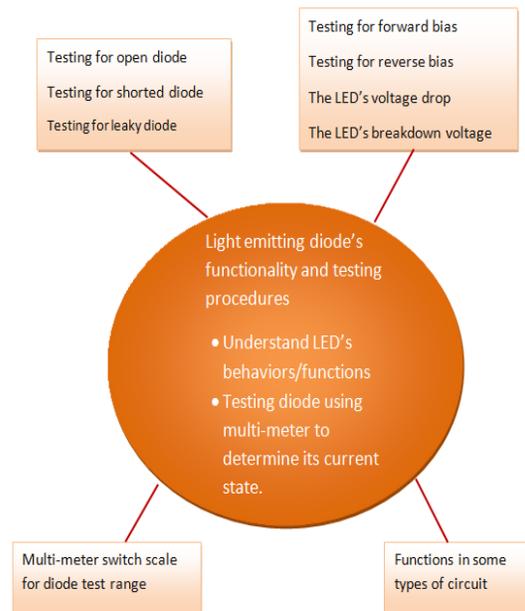


Figure 4. Concept Map on Light Emitting Diode

**Installation and Deployment.** In this phase, the developed software will be thoroughly tested and gaps, errors and other missing elements will be fixed. The product will be sent to the client for evaluation and feedback or change request. Finally the finished product will be delivered. The software will be installed in a local area network, users will be trained and the flow and stability of the software and its infrastructure will be maintained and the user’s manual will be distributed to the users of the system.

**RESULTS AND DISCUSSION**  
**The E-Learning Modules**

The developed E-learning consists of two main modules: Learning Management and Student Module. The learning management module was coded using Visual Basic.NET programming language and MYSQL 5 was used as backend database server. Reports are automatically sent to MS Excel for viewing and printing. The Student Module was developed using Flash.

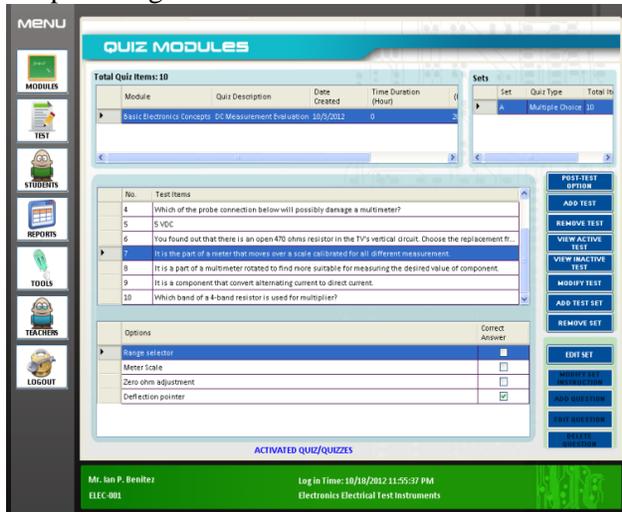


Figure 5. Learning Management System (LMS)

Figure 5 illustrates the Learning Management System window. This module was used by the subject instructor such as adding courseware, importing and managing class, generating reports, performing maintenance such as changing data parameters and database backup and restore.

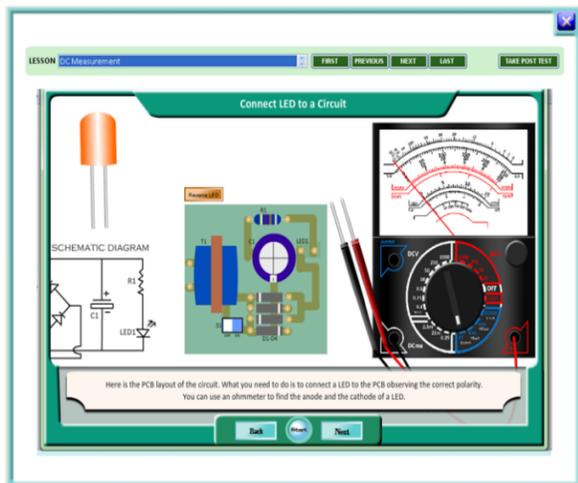


Figure 6. Connecting LED to a Bridge-type Power Supply

Figure 6 shows the courseware activity to practice students' skills in connecting a LED to a circuit as power indicator.

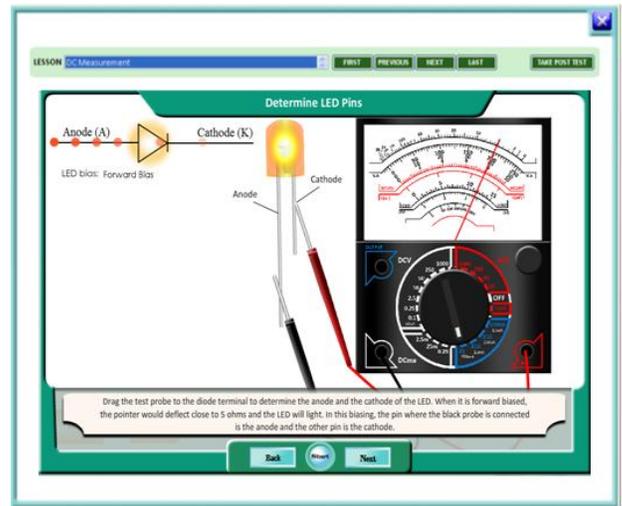


Figure 7. Finding LED pins with Multi-meter

Figure 7 shows the courseware activity to practice students' skills in identifying LED pins using multi-meter instrument.

**Client-Testing**  
**Achievement of the students**

Table 3. T-Test of the Pretest and Posttest Result

RESPONDENTS	PRE-TEST	POST-TEST
1	60	100
2	70	95
3	75	95
4	60	95
5	65	95
6	60	95
7	50	90
8	50	90
9	65	90
10	55	90
11	65	85
12	55	85
13	55	85
14	70	85
15	50	80
16	70	75
17	55	75
18	65	75
19	50	75
20	50	70
	<b>59.75</b>	<b>86.25</b>
	Mean Difference = 26.50	
	Computed T-Test = 2.25	

The Computer-based training was evaluated in terms of its effectiveness in enhancing the learning of the students after going through with the learning modules. The participants in the client-testing of the learning modules were the 20 freshmen Electronics Communication Servicing students. T-Test was used to compare the pre-test and post-test result in order to determine whether the students achieved learning after studying the learning modules. The result is shown in Table 3.

The statistical measure which yields a value of 2.25 which is higher than the table of critical t values at 5% level of significance. The result revealed that there is a significant achievement of the students after studying the learning module.

The graph in figure 8 shows the comparison between pre and post-test which was charted using SPSS software.

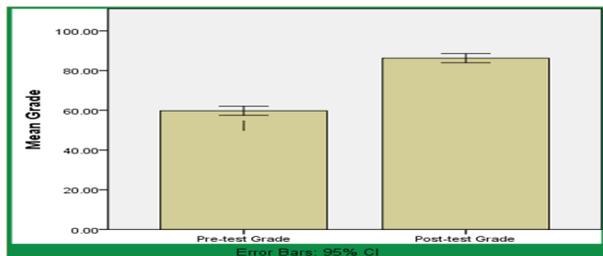


Figure 8. Graph of Pre-test and Post-test Result

**Evaluation of the Learning Modules by Instructors**

The proponent chose five (5) instructors from the College of Information and Communications Technology (CICT) and five (5) from the College of Engineering (COE) at Camarines Sur Polytechnic Colleges using purposive sampling for the evaluation of the learning modules to assess if the courseware is sufficiently valid in terms of contents, activities, assessment and format.

Table 4 gives the summary of the validation of the learning modules done by five (5) instructors from CICT department and five (5) from the College of Engineering. It shows that the overall weighted mean  $W_m = 4.35$  which gives a verbal interpretation of Sufficient. The average weighted mean of validation in terms of content is 4.40 which have a verbal interpretation of Sufficient. In terms of the activities, the average weighted mean is 4.40 which give a verbal interpretation of Sufficient. In terms of evaluation, it gives an average weighted mean of 4.40 which have an interpretation of Sufficient. The format of the learning modules obtained an average weighted

mean of 4.20. The overall weighted mean of 4.35 gives a verbal interpretation of Sufficient. The grand average/weighted mean evidently shows that the contents, activities, evaluation and format of the proposed learning modules are sufficiently valid in terms of contents, activities, assessment and format.

Table 4. Validation of Instructors on the Courseware

Item	Wm	Verbal Interpretation
Contents	4.40	S
Activities	4.40	S
Assessment	4.40	S
Format	4.20	S
Over-all Weighted Mean	4.35	S

**CONCLUSION AND RECOMMENDATION**

A computer-based training was developed to provide a supplemental tool in enhancing the learning process of students on topics in Fundamentals of Electronics. Utilizing the developed computer-based training in teaching the subject enhanced the performance of the students in actual works in basic components and testing procedures with multi-meter test instruments. It also enhanced the knowledge of the students in the theoretical aspects of electronics. Likewise, the incidents of test instruments damage when testing voltages and testing components in-circuit were reduced. Overall, it increased the efficiency of the students in the assembly and repairs of simple electronics devices particularly, the Linear DC Converter. The courseware was validated by various instructors as sufficient in terms of its contents, activities, assessment and format. This shows that supplementing the teaching with the developed software enhances the teaching-learning process in Fundamentals of Electronics.

The proponent presents the following recommendations: the developed computer-based training may be used by the instructors and students of fundamentals of electronics courses to supplement the traditional learning methodology. In the progression of the computer-based training’s utilization, instructors and students are encouraged to give additional comments and suggestions to further improve the learning outcome of the students.

The computer-based training is subject for further improvements through courseware modification to be updated with the latest version of Consumer Electronics Servicing Training Regulation. The developed courseware was focused on basic

electronics concepts but more courseware maybe developed to use in other fields of electronics as well. Simulations and scenario-based learning can be integrated in the contents for more realistic activities. Also, the learning management module can be redesigned as a web-based application in order to be deployed online to be accessible through the Internet. Further study may be conducted to test the effectiveness of the courseware using experimental design.

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