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THE STUDY ELECTRICAL CIRCUIT TEST KITS AND DAMAGES ANALYSIS OF AIR CONDITIONING FOR EMPOWERING LEARNERS

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Abstract

The objective of this research is to empower learners who study with circuit test kits and damages analysis of air conditioning in conjunction with the experimental worksheets that have been prepared. The researchers used the tryout group to research 20 students who had completed refrigeration and air conditioning classes by selecting a specific method, finding that overall, the sample was strongly agreed ($\bar{X}$ = 4.50, S.D. = 0.50) and in comparing academic achievements and evaluating student feedback, the sample was defined as students. The power electrician who has not yet enrolled in refrigeration and air conditioning courses semester 2 of the 2021 academic year was obtained by selecting 20 specific students based on the criteria, and it was found that the electrical circuit test kits and damages analysis of air conditioning could be used to effectively conduct instructional activities in conjunction with experimental worksheets at the criteria, 81.90/81.70 was higher than the established at 80/80 threshold with the academic achievement of the post-test sample, an average being statistically significantly higher than pre-test, the .05 level and the overall opinion was strongly agreeable., ($\bar{X}$ = 4.56, S.D. = 0.45)

Keywords: Air conditioning, Electrical circuit, Test kits damages analysis

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Introduction

Department of industrial education, Faculty of education srinakharinwirot university has realized the importance of providing learner-focused instruction by using an integrated teaching and learning approach to various subjects so that learners can develop holistic professional skills in terms of knowledge, process skills, career skills that can be applied to their surroundings, have intelligence and resourcefulness, develop good habits for work and society, as well as develop learners to be in accordance with the national education act in accordance with the quality of economic, social, cultural, environmental and technological conditions. It is a learning that encourages learners to come up with new skills and experiences and experiences with a systematic process be in line with Asma Abdulrahman Nami Alshaikh, the use of virtual a lab is an advanced cognitive development that enables learners to succeed in providing virtual instruction. (Asma Abdulrahman., & Nami Alshaikh, 2022, pp12)

The electrical-industrial education to curriculum in course provides courses that respond to changes in the 21st century that focus on the development of skills and technology. Refrigeration and air conditioning is one of the courses. Nowadays, refrigeration and air conditioning are electrical appliances that are necessary for the livelihood of Thai people. Office buildings, factories, or even classrooms all use refrigeration and air conditioning. Therefore, in the courses of teaching in this course, both theoretical and practical aspects of mechanical devices. Electrical equipment Mechanical and electrical circuits, instrumentation, damages of analysis, as well as Maintenance and operational safety be in line with Pornthana, it said that training kits and experimental kits can enable learners to study, research and develop learning on their own effectively, (Pornthana Juajarn, 2018) and be in line with Mhamed Ben Ouahi et al., teaching and learning using computer simulations has resulted in the development of learner's performance in the physical sciences. The field of electrical ohm's law. The learners had significantly improved learning management outcomes at 0.05. (Mhamed Ben Ouahi., Mohamed Ait Hou., Abdesselam Bliya., Taoufik Hassouni., & El Mehdi Al Ibrahmi, 2021, pp 10)

Therefore, practical teaching is a type of teaching method that uses problem solving and gives learners the opportunity to analysis, act in practice and conduct experiments to find knowledge for themselves, learners are self-proficient, which is experiential learning, so educational institutions must focus on experimental teaching research, reforming experimental education. To make the quality of teaching effectively meet the needs of learners. (Wipada Wongsuriya, Pattanapong Sinpaitoon & Peerapong chanhom, 2020, pp 68-174)

But because of the refrigeration and air conditioning training kits that are currently in use. It was found that it was only an electrical circuit extension. Wipada et al., have developed the development of electrical circuit training package of split type air conditioning on refrigeration and air conditioning (Wipada Wongsuriya, Pattanapong Sinpaitoon & Peerapong chanhom, 2020, pp 68-174). Asada et al., The studied to development of a training kit for electrical circuit connection in air conditioner (Asada Wannakayont, Nikom Lonkuntosh & Teangtum Sittichantasen et al, 2019, pp 163-178) and Puchong has created. A construction and efficiency validation of training package on air conditioner: Mechanical and electrical circuit of the refrigeration and air conditioning. (Puchong Chanjira, 2011)

Therefore, for the reasons, providing hands-on or experimental instruction through skill training kits is effectively empowering learners. Therefore, researchers realized the importance of integrating innovation and

technology in the study approach, designing, developing electrical circuit test kits, damages analyzing of air conditioning for the empowerment of both theoretical and experimental learners in practice. It also generates interest in the learner with an experimental approach, allowing learners to learn through hands-on experience, as well as comparing the academic achievements of the learners studying with the electrical circuit test kits and analyzing damage of air conditioning from the worksheets provided.

Purpose

1) Design and manufacture the study electrical circuit test kits and damages analysis of air conditioning for empowering learners.

2) Determine the efficiency of the study electrical circuit test kits and damages analysis of air conditioning for empowering learners.

3) Compare the learning achievements of students studying with the study electrical circuit test kits and damages analysis of air conditioning for empowering learners and worksheets that have been prepared.

Expected Benefits

1) Electrical circuit test kits and damages analysis of air conditioning for empowering learners (EIE 322) according to the graduate education curriculum. single major Major in Industrial Studies - Electrical Faculty of Education Srinakharinwirot University.

2) Learners have developed practical skills from the the study electrical circuit test kits and damages analysis of air conditioning for empowering learners and the experimental worksheet created.

3) Reduce the time for teaching and learning. by the study electrical circuit test kits and damages analysis of air conditioning for empowering learners and experimental worksheets created because it is a medium that enhances understanding There is motivation for learners to have the intention to study. and participate in teaching and learning.

4) To be a prototype in the production of the study electrical circuit test kits and damages analysis of air conditioning for empowering learners for teaching students in other institutions.

Importance of research

This series of the study electrical circuit test kits and damages analysis of air conditioning for empowering learners and the experimental worksheet created it can be used as a medium to strengthen understanding and stimulate learners' learning intention.

Research scope

Research scope implementation There are details of the scope of implementation of the project as follows.

1) Scope of course content EIE 322 Refrigeration and Air Conditioning

2) Population and sample

(1) The research population were first-year vocational certificate students in Power Electrician. Kanchanapisek Nongchok Industrial and Community Education College, semester 2, academic year 2021, 2 classrooms, 40 students per classroom.

(2) The research sample is a first-year diploma student majoring in Electrical Engineering at Kanchanapisek Nongchok Industrial and Community Education College. The second semester of the 2021 academic year will be selected by 20 students through specific selection.

3) Air conditioner Used 9000 BTU.

Materials and Methods

Theories

Teaching experimental practices

The experimental teaching is very important to industrial studies learners because it develops learners from real-world experiences, gives them the opportunity to learn about academic content, practices their skills through the theoretical process to prove facts, create accurate and clear understandings or to gain new knowledge from phenomena that occur through different experiments of theory. Learners can integrate activities that combine brain, physical abilities and develop a positive attitude towards teaching and learning. (Somjai Intanont Pinyo Saisrikaew & Panumet Suksrisiriwat, 2015, pp 81-88) In teaching experimental practice, the instructor must know the material to be taught and must understand the practical steps. [8] Therefore, experimental teaching consists of 3 aspects: 1) the role of the instructor in the field of teaching and conducting experimental practices. 2) The sequence of procedures for teaching experimental practices and 3) types of practical and experimental activities.

The role of instructor, even if the one who defines the learner as the one who acts on his own. But instructors also play a role in teaching. The instructor will act as a caregiver to assist, advise, encourage learners to be interested in conducting experiments. The role of an experimental instructor can be divided into three stages: 1) Pre-trial discussion; Instructors must prepare questions before teaching to encourage learners to want to know, want to see, think doubt, or suggest guidelines for them to continue of find answers. Promoting self-discovery may prove what others have already discovered while also researching new things as a tool exercise. Observation collection of information. In teaching and learning, instructors must provide close guidance, encouragement support and mentorship throughout. The trial not let learners experiment unilaterally. Instructors must prepare questions to enable learners to use the data or experimental results they collect. Summary is a set of rules, theories, or principles, as well as a discussion of the errors made. (Puchong Chanjira, 2011)

The basic working principles cooling and air conditioning.

It is the process of transferring heat out of the area where the temperature needs to be lowered and the temperature is controlled to be stable by using refrigerant as a cooling medium. The based on the principle of changing the state of refrigerant from liquid to vapor, heat is absorbed from neigh boring areas, thereby

causing the area to lower the temperature or cool down. (JegeleviCius, D. Pagodinas, D. & Dumbrava, V., 2010, pp. 107-110)

The cooling and air conditioning cycle has four main components: compressor, hot coil; The pressure-reducing valve and cooling coil and when the refrigerant flows through the four parts of the device form a cooling cycle. The initial process is as follows: The compressor receives the refrigerant heat exchanger from the cold coil through it along copper pipe No. 1, according to Figure 1. It then sucks and compresses the refrigerant to increase the temperature and pressure of the refrigerant, then changes its state from vapor to liquid and passes it into the hot coil along copper pipe No. 2. The heat in this copper pipe is the highest temperature when the refrigerant flows into the coil, the hot coil circulates indefinitely. While the refrigerant flows in the hot coil panel, there is a blown fan to help cool the heat faster, causing the refrigerant leaving the hot coil to have a lower temperature, but the pressure remains that is then passed on along copper pipe No. 3. The go to pressure reducing valve in copper pipe No. 3. The temperature of the refrigerant is less than copper pipe no. 2. When the pressure and temperature drop are low, the refrigerant changes the state from liquid to vapor and then flows along copper pipe No. 4, where copper pipe No. 4, the refrigerant contained in copper pipe No. 3 and No. 2. Then the refrigerant flows vortex through the cooling coil panel, with a blowing fan to help absorb heat from inside the room to cause the room temperature to drop, which causes the refrigerant leaving the coil to have a higher temperature, the constant pressure is transmitted along copper pipe No. 1. Return to the compressor for further cooling cycle rotation. (Puchong Chanjira, 2011)

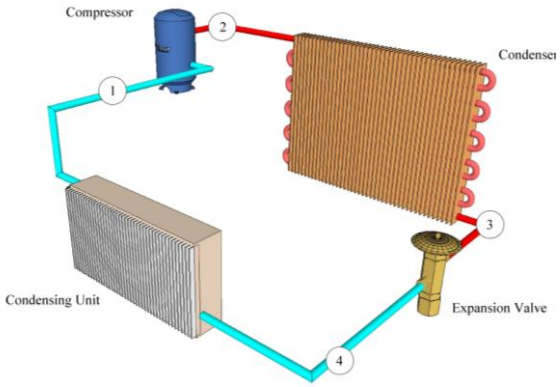


Figure 1 *The cycle of cooling and air conditioning.*

The modular air conditioning of electrical circuit.

The modular air conditioning circuit separates the power circuit into two parts: the evaporator, cooling coil and the lighting circuit part of the condensing unit, which requires an additional condenser fan motor.

As for the circuitry, the evaporator set coiling coil consists of a terminal and a selector switch, which is attached to the fan motor at slow, medium, and high speeds. This fan motor sucks air from inside the room through the cooling coil and has a thermostat which controls the condensing unit. (Thiraphong Borirak & Pongsawat Kochapoom, 2013, pp 57-64)

The electrical circuit of condensing unit consists of magnets, contactors, compressor motors and condenser cooling fan motors. The control power circuit from the thermostat passes through the magnet contactor cooling coil, causing the contacts to the compressor motor and the condenser fan motor to work simultaneously, and when the air temperature in the room drops to the point of adjustment, the contacts of the thermostat from the power that feed the magnet contactor's cooling coil cause the contacts from the stop working of the device through the condensing unit, but at the same time the fan motor of the unit continues to operate normally until the air temperature in the room rises, causing the contacts of the thermostat to once again be lit to feed the coils of the magnet contact unit. (Ely Donald, P., 1972), (Somsak Sumotayakul, 2016)

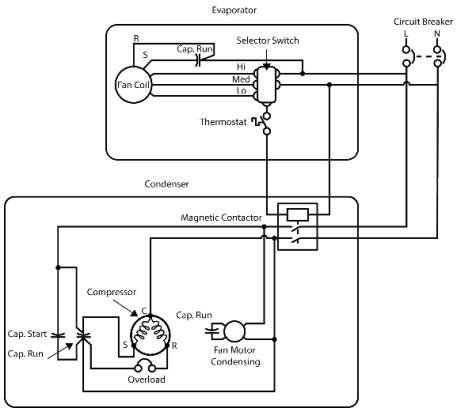


Figure 2 *The modular air conditioning of electrical circuit.*

A inspection of modular air conditioning components.

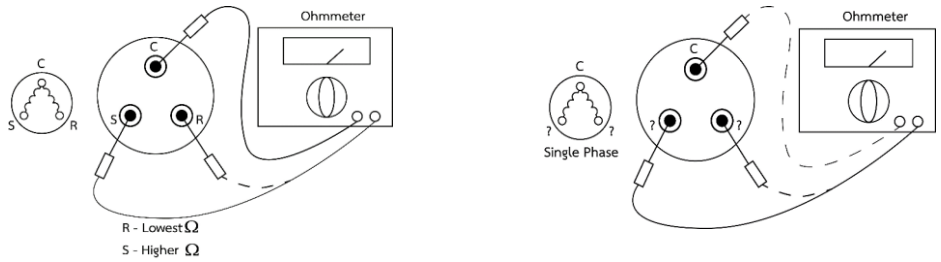
1) The compressor motor of inspection. (Somsak Sumotayakul, 2016)

(1) The check to rotation of the compressor motor, if the compressor is poorly released, check the bracketing force between the C terminal and the R terminal, but if the moving force is normal, check the equipment such as the starter assist unit and capacitor run., etc.

(2) The check to compression of the compressor motor, install the pressure gauge on both the low-pressure side and the high-pressure side, after the operation of the machine, the pressure must vary about 150-200psi depending on the type of cooler.

(3) The check for polarity of compressor motor. Generally, manufacturers design the common terminal (Common; C) above the run (Run; R) terminal on the right and starter terminal (Start; S) is on the left. But if there is no symbol indicating the main terminal of the compressor. It can be found by measuring the resistance of the motor windings as follows: 1) Cut off the power from the compressor source, 2) Disconnect the wires from the compressor core, 3) Use an ohmmeter (Ohmmeter) to set R×1 to the main terminal, pair by pair. The highest measured pair is value of the S – R pole, so the remaining pole will be C pole.

(4) Once the C terminals are known, they must find out which poles are the S and R terminals. If the minimum resistance is obtained, it R pole, so the remaining polarity is S terminal.



(A) Find a common pole(C). (B) Find the R and S terminals.

Figure 3 *Verifying the compressor motor polarity.*

2) The inspection of condensing motors. (Kongpradit, Teepjatupon, และ Iqbal, 2020, pp. 96-105)

(1) The check to rotation of the condensing motor. If the condensing motor starts off or rotates more slowly than usual, check the force of movement between the C and R terminals, but if the force moves normally, check for devices such as start assists and capacitors., etc.

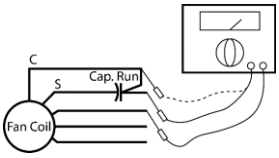
(2) The check for the polarity of condensing motor, use the same inspection method as checking for the terminals of the compressor motor.

3) The evaporator motor of inspection. (Dale & Edgar, 2016)

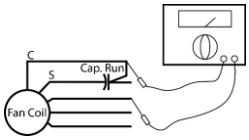
(1) The check to rotation of the evaporator motor. If the evaporate motor is not working properly, check the creeping force between the C and R terminals, but if the force moves normally, check for devices such as start assists, capacitors., etc.

(2) Perform rotation check of evaporator motor. If the evaporator motor cannot adjust the speed or can use a single speed, check the polarity of the evaporator motor.

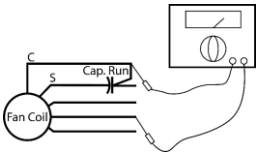
(3) The check of evaporator motor terminals. Generally, the manufacturer designs run terminal (Run; C) on the upper line, the start terminal (Start; S) is next to it and HI, MED, LOW terminal is on the bottom line respectively, or it may be defined with black instead of blue HI terminal instead of red MED instead of white LOW instead of the terminal C. 1. Cut off power from the source entering the evaporator motor. 2) Disconnect the various wires from the evaporator motor. 3) Use ohmmeter, set R×1, measure, check to the main terminals one by one. The maximum measured pair is the value of the S – R (HI, MED, LOW) terminals, so the remaining poles are terminal C. 4) If the minimum resistance is the R (HI, MED, LOW) terminal, then the remaining polarity is the terminal S pole, but because there is a speed-controlled evaporator motor, we need to find the resistance value in the terminal R coil unit. Using the terminal C pole primarily, and then measuring the resistance in the coil set terminal R, the greatest resistance value is the LOW pole, the least resistance value is the HI terminal, the remaining pole is the MED terminal.



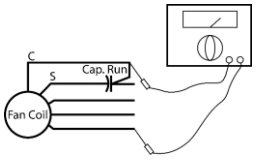
(A) Find the common terminal (C).



(B) Find the R and S terminals.



(C) Find the HI terminal.



(D) Find a LOW terminal.

Figure 4 *Verifying the evaporator motor terminals.*

The inspection of electrical control equipment of modular air conditioners.

1) Magnetic contactor is another type of switch consisting of two important parts: the part that is the coil when the current is fed into the coil, the magnetic field is generated and the other part is the contact of the magnetic contactor to the power circuit fed into the load, so the damage may occur from 2 parts. (Chusak Plianphu., 2008)

(1) The caused by arcing of the contacts, the contacts are not completely in contact with each other, or the contacts melt next to each other, ohmmeters can be used. A set R×1 gauge into check with contact terminals.

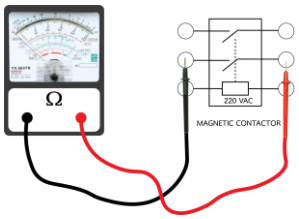


Figure 5 *Verifying of inspecting the magnetic contactor contacts.*

(2) The caused by a broken coil, can use ohmmeter to set R×1 monitor to the coil terminal or coil.

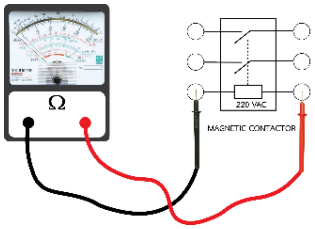


Figure 6 *Verifying the magnetic contactor coil.*

2) Overload is a device to prevent the compressor motor from being damaged when the refrigeration. The system is disrupted and if the compressor motor consumes too much current. Overload breaks the power circuit fed into the compressor motor before the motor's winding burns out. Ohmmeter can be used to set the R×1 measurement to check at the terminals of overload.

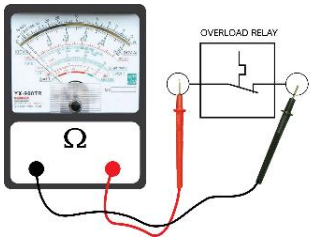


Figure 7 *Verifying of the overload.*

3) High pressure control is a device that connected to the discharge tube of the compressor. It prevents harm to the refrigeration system when the pressure in the system is higher than normal. Ohmmeter can be used to set R×1 to measure monitoring at the terminals of High-pressure control.

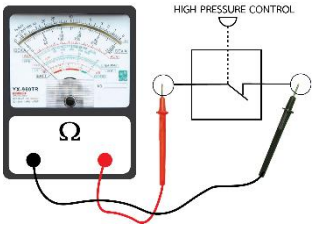


Figure 8 *Verifying of High-pressure control.*

4) Low pressure control is a device that is attached to the washing pipe of the compressor, performing two functions: The preventing harm from occurring to the refrigeration system when the pressure in the low-pressure system is abnormally low. The low-pressure reagent control device breaks the electrical circuit entering the compressor to stop the system from operating and when the pressure rises to normal pressure, an ohmmeter can be used (Ohmmeter) set R×1 measuring monitor to low pressure control terminals.

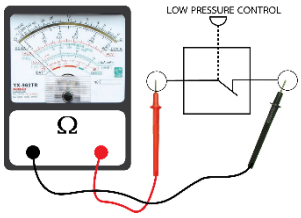


Figure 9 *Verifying of Low-pressure control.*

5) The capacitor is designed to help solve motor's power factor and reduce the current intake of the motor. Therefore, capacitor run must always stay on circuit. The capacitor verifying to check the capacitor, first disconnect the cable from the capacitor's main terminal and discharge it from the capacitor. Using an insulated wire or screwdriver, the handle touches between the two main terminals of the capacitor. The to prevent damage of measuring instrument. Discharging out of the capacitor by this method Capacitor manufacturers do not recommend using high resistance values to connect between the two main terminals to discharge from the capacitor. After discharging the capacitor, set multimeter at R×10k measured into both main terminals. Observe the effect on needle of ohmmeter as follows.

(1) If the needle swings up and then gradually drops to its original position, then the capacitor is normally good.

(2) The Switch to wires of multimeter, if the needle swings up and then gradually lowers to its original position, then the capacitor is normal.

Figure 10 *Verifying of the capacitor.*

(3) The ohmmeter's if needle swings up and holds, then the capacitor is shocked between the plates.

(4) The needle if the ohmmeter does not rise at all. It indicates that the capacitor terminal lacks both.

Research framework

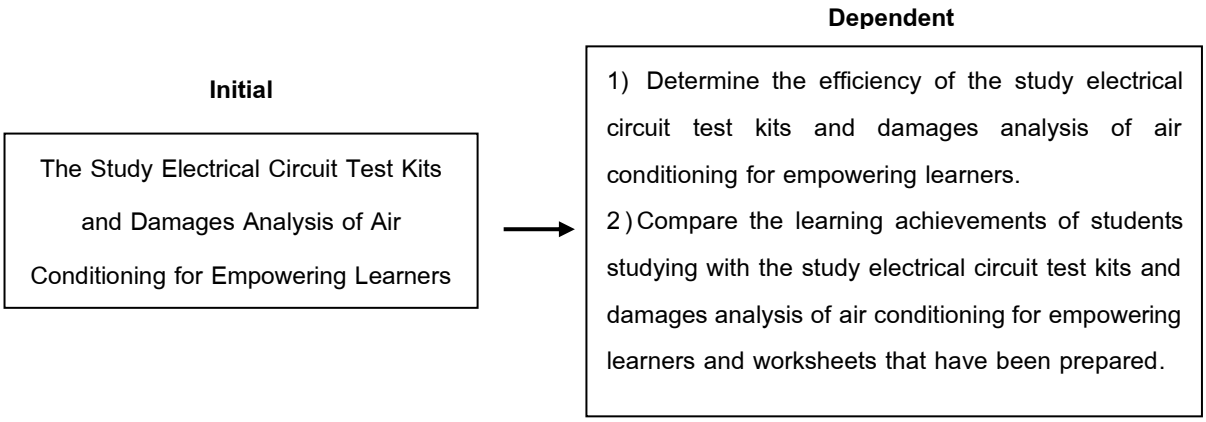


Figure 11 *Research framework.*

Assumptions in research

In this research, the researcher has formulated the assumptions of the research as follows.

1) Electrical circuit testing and analysis of air conditioning faults and worksheets Has developed, created, can be used in teaching and learning as effectively as 80/80.

2) Learners who study with electric circuit test sets and analyze the symptoms of air conditioning and Experimental worksheets that have been developed will have higher learning achievement after learning than before learning with statistical significance

The research methods of conducting.

The design of electrical circuit test training kits and analysed the damage of air conditioner.

Therefore, the researchers designed experimental kits with the characteristics of experimental panels, Plug-in Modules and Plug-in Components.

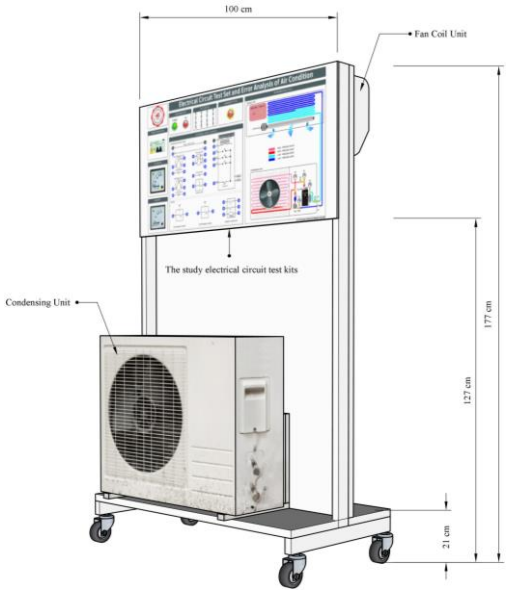


Figure 12 *The model of electrical circuit test kit and damages analysis of air conditioning.*

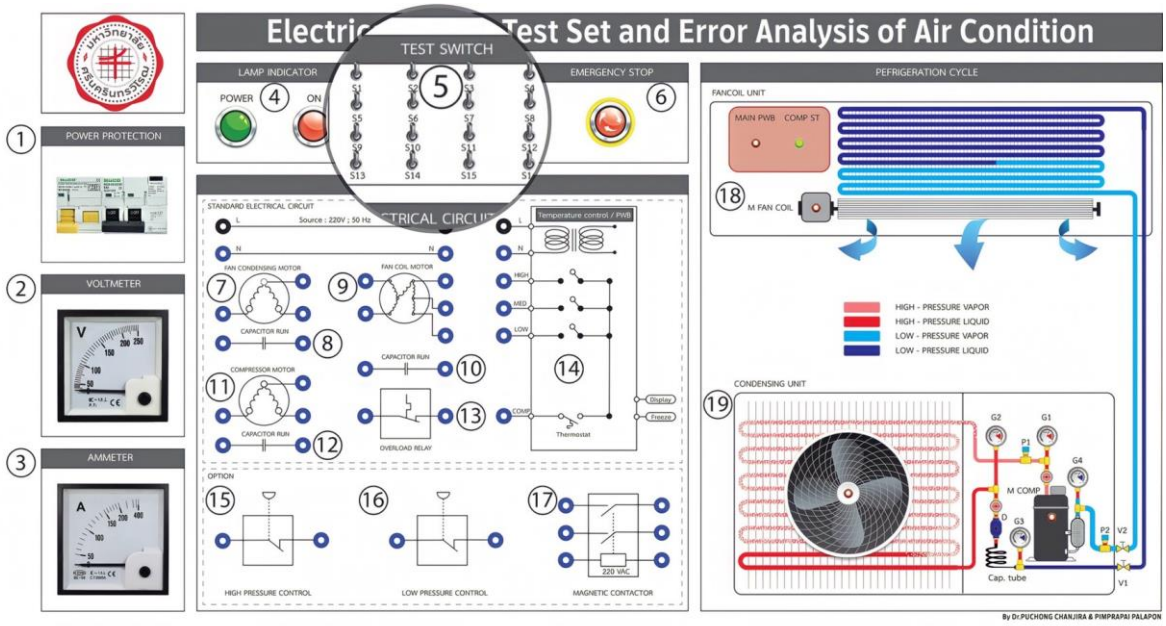


Figure 13 *The experimental panels a training kit to test electrical circuits and analysed air conditioner damages.*

As, Figure12: Contains the symbols of number circuit, ① Power Protection, ② Voltmeter, ③ Ammeter, ④ Lamp Indicator, ⑤ Test Switch, ⑥ Emergency, ⑦ Fan Condensing Motor, ⑧ Capacitor Run, ⑨ Fan Coil Motor, ⑩ Capacitor Run, ⑪ Compressor Motor, ⑫ Capacitor Run, ⑬ Overload Relay, ⑭ Temperature Control / PWB, ⑮ High Pressure Control, ⑯ Low Pressure Control, ⑰ Magnetic Contactor, ⑱ Fan coil Unit and ⑲ Condensing Unit

The experimental panels are made of acrylic, with the symbol of circuit above printed. Connect the device in batches or finished circuits. The experimental panel is designed as banana plug-in modules with safety type to reduce accidents due to short circuits. It is separated into individual components of the equipment in air conditioner so that students can test the electrical circuits and analysed the damage of air conditioner in each part, such as compressor motor, fan condensing motor and magnetic contactor etc.

The analysed of damage in air conditioners, the researchers designed the Normally Close 1-way-switch as a device to determine the damage and error of the air conditioner in each situation by shuffling the switch to turn on the circuit. Without knowing which part of the switch, the instructor performed, the learner could study and analysed the damage of the air conditioner in each situation, each of which (⑤ Test Switch) was attached to the interior of each device in the test kit for a total of 16 positions separated by the following circumstances:

The evaluate to performance of electrical circuit test training kit and analysis the damage of the air conditioner.

For empowering the potential of learners in conjunction with the population (Try Out) in the research was 20 students at 3rd year vocational certificate level who had completed the course of refrigeration and air

conditioning courses by means of specific selection. This research study include: 1) Electrical circuit test and air conditioner damage analysis training kit. 2) Experimental worksheet. 3) Performance assessment form.

Assessment of academic achievement.

The learners who studied with electrical circuit test kit and analysis damage of air conditioning in conjunction with the worksheet, the population and sample were determined: 1) The research population is a first-year diploma student in the field. Electrician power kanchanapisek nongjok vocational college who has not yet enrolled in refrigeration and air conditioning courses. Semester 2 academic year 2021: 40 people. 2) Samples were obtained by selecting a specific method of 20 people according to the specified criteria. The tools used to collect data for this study include. 1) electrical circuit test kits and damages analysis of air conditioning. 2) Experimental worksheets. 3) Tests to measure learning achievement from electrical circuit experiments. 4) Student feedback questionnaire as a sample.

Statistics used in research.

This experiment was conducted as a one-group pre-test – post-test design experiment by conducting research as shown in Table 1.

Table 1 One - Group Pre-test - post-test Design Research Model.

Group	*Pre-test*	*test*	*post-test*
Sample	T_1	*X*	T_2

where, T_1 is pre- test of experimental measurement.

X is learning test with a tryout.

T_2 is post- test of experimental measurement.

Finding the effectiveness of experimental sets and analyzing academic achievement.

1) The statistics used to determine efficiency of training kit, test electrical circuits and analyze the damage of the air conditioner.

$$E_1 = \frac{\frac{\sum X}{N}}{A} \times 100 \quad (1)$$

$$E_2 = \frac{\frac{\sum F}{N}}{B} \times 100 \quad (2)$$

where, E_1 = Instead, the achievement value is a percentage of average score from the entire end of experiment test.

E_2 = Instead, the achievement value is a percentage of average score from the total test from all trials.

$\sum X$ = The total score of tests at end of experimental.

$\sum F$ = The total score of combined tests.

A = The full score of tests at end of experimental.

B = The total score of total tests.

N = The total number of students.

The statistics used to analyze academic achievement.

The analysis to test significance of academic achievement which is a score from doing a pre-learning achievement test with an electric circuit training kit and after studying with electric circuit training kit using the formula *t* - dependent sample test.

$$t = \frac{\sum D}{\sqrt{\frac{N\sum D^2 - \sum D^2}{n-1}}} \quad (3)$$

when, $\sum D$ = The sum of differences between test scores after using the teaching style and before use of teaching style.

$\sum D^2$ = The sum of squares, the difference between test scores after using teaching style and before use of teaching style.

N = The number of students in sample.

Content-based accuracy analysis by finding a content-based consistency index has the following criteria:

$$IOC = \frac{\sum R}{N} \quad (4)$$

when, IOC = Consistency of index between exams and objectives.

R = Sum of all content expert opinion scores.

N = Number of content professionals.

Arithmetic mean.

$$\bar{X} = \frac{\sum X}{n} \quad (5)$$

when, $\bar{X}$ = arithmetic mean.

$\sum X$ = Positive result of all data values.

n = Total data count.

Interpretation from the mean ($\bar{X}$)

A value $\bar{X}$ is between 1.00 – 1.49, means strongly disagree.

A value $\bar{X}$ is between 1.50 – 2.49, means disagree.

A value $\bar{X}$ is between 2.50 – 3.49, means unsure.

A value $\bar{X}$ is between 3.50 – 4.49, means agree.

A value $\bar{X}$ is between 4.50 – 5.00, means strongly agree.

Standard Deviation.

$$S.D. = \sqrt{\frac{\sum X - \bar{X}^2}{N-1}} \quad (6)$$

when, *S.D.* = Standard deviation.

X = Comment level value.

$\bar{X}$ = Mathematical average of opinion levels.

N = Number of students who responded to questionnaire.

The interpretation from standard deviation., (S.D.)

S.D. value is small, indicating that respondents have the same opinion.

S.D. value is very valuable, this indicates that respondents have different opinions.

Results and Discussion

The results of design and construction of electrical circuit test kits and damages analysis of air *conditioner*.

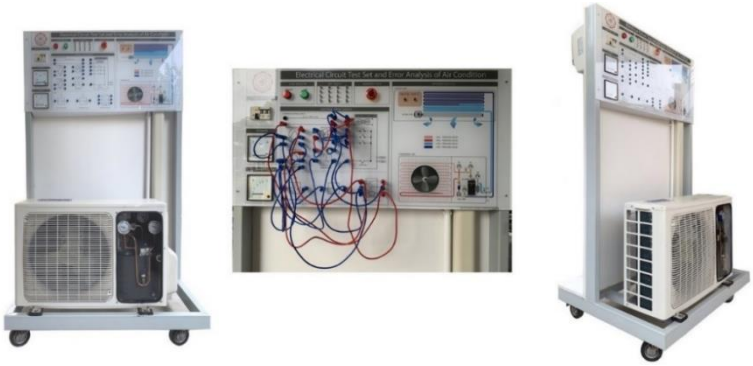


Figure 14 *A electrical circuit testing kit and damages analysis of air conditioner.*

The results of evaluation of the opinions in populations who are not try out sample group towards the electric circuit test and damages analysis of air conditioners together with experimental worksheet.

Using a non-sample population of 20 people, the trial was divided into four areas: 1) Behavioural objectives, 2) Content, 3) Experimental kit, 4) Experimental worksheet, with analysis showing mean ($\bar{X}$) and standard deviation (S.D.).

Table 2 Overview of the evaluation of the performance of the electrical circuit test training kit and damages analysis of air conditioning in conjunction with the experimental worksheet.

Topics	*Level*	
	$\bar{X}$	*S.D.*
1. Behavioral objectives	*4.47*	*0.48*
2. Content	*4.49*	*0.55*
3. Experimental kit	*4.52*	*0.48*
4. Experimental worksheet	*4.50*	*0.48*
Total	*4.50*	*0.50*

From table 2, it was found that overall performance assessment was at a highly agreeable level ($\bar{X}$ = 4.50, S.D. = 0.50). The content side, it was found that the highest mean was the experimental set ($\bar{X}$ = 4.52, S.D. = 0.48), secondary. The following items were the experimental worksheet ($\bar{X}$ = 4.50, S.D. = 0.48), content ($\bar{X}$ = 4.49, S.D. = 0.55) and lowest mean item was the behavioural objective ($\bar{X}$ = 4.47 , S.D. = 0.48), respectively.

The educational achievement and efficacy results of experimental set.

Learners studying with an electrical circuit test kit and damages analysis of air conditioning in conjunction with an experimental worksheet, based on research assumptions; 1) Test kits can be used in teaching and learning as effectively as 80/80, 2) the learners who study with the practice test have the achievement post-test learning was statistically significantly higher than before. The researcher conducted teaching with a practice test set together with an experimental worksheet using a research sample as well as 20 first-year diploma students with a specific selection method.

Figure 15 *Learners studying with a set of electrical circuit tests and damages analysis of air conditioning in conjunction with an experimental worksheet.*

The results of electrical circuit test training kit and damages analysis of air conditioning in combination with the experimental worksheet.

Table 3 The results of implementation the electrical circuit test and damages analysis of air conditioning in combination with the experimental worksheet.

The total in 20 students.	Worksheet test scores					Post-test scores (50 points)	Achievement-test scores (50 points)
	Experiment worksheet no. 1 (10 points)	Experiment worksheet no. 2 (10 points)	Experiment worksheet no. 3 (10 points)	Experiment worksheet no. 4 (10 points)	Experiment worksheet no. 5 (10 points)		
Total score	166	163	167	160	163	819	817
Average	8.3	8.15	8.35	8.00	8.15	40.95	40.85
%	83.00	81.50	83.50	80.00	81.50	81.90	81.70

From, Table 2 it was found that process efficiency (E1) is 81.90, the resulting efficiency (E2) is 81.70, indicating that electrical circuit test and damages analysis of the air conditioner efficiency 81.90/81.70 calculated following:

$$E_1 = \frac{\frac{\sum X}{N}}{A} \times 100 \quad (7)$$

$$= \frac{\frac{819}{20}}{50} \times 100$$

$$E_2 = \frac{\frac{\sum F}{N}}{B} \times 100 \quad (8)$$

$$= \frac{\frac{817}{20}}{50} \times 100$$

$$= 81.70\%$$

The applying by electrical circuit test kits and damages analysis of air conditioning in conjunction with the experimental worksheet, it was found that the effectiveness of the results of test kits and the developed experimental worksheets can be applied to the sample by conducting post-test with test kits and worksheets with an average accuracy of percentage, which is higher than the assumption threshold set and the sample that completed the achievement test was 81.70%, which is higher than the latter threshold, thus showing that the test kits and experimental worksheets developed could be used to provide instruction with an efficiency of 81.90/81.70, higher than the 80/80 threshold set forth in Table 4.

Table 4 The results to efficiency of experimental and analysis of learner achievement test.

Topics of score.	Total	Average	S.D.	%	Efficiency of experimental (E_1/E_2)
Post-test Quizzes	50	40.95	0.88	81.90	81.90/81.70
Achievement test	50	40.85	0.87	81.70	

The results to analysis of achievement test by learners studying with a test kit in combination with developed experimental worksheet.

There will be, Academic achievement of after learning, it statistically significantly higher than before learning shown in Table 5.

Table 5 The analysis of after-learning and before-learning test scores.

The total in 20 students.	Before - learning score		After - learning of score		$D = X_2 - X_1$	D^2
	X_1	X_1^2	X_2	X_2^2		
Total	569	16485	817	33389	248	3416
Average	28.45	824.25	40.85	1669.45	19.25	-
%	56.90	32.97	95.40	66.778	-	-

From, Table 8 is analysis of after-learning and before-learning test scores. The researchers then analysis its *t* - dependent sample test the significance of student's academic achievement as follows,

$$t = \frac{\sum D}{\sqrt{\frac{N\sum D^2 - \sum D^2}{n-1}}} \quad (9)$$

$$t = \frac{248}{\sqrt{\frac{(20 \times 3416) - (248)^2}{19}}}$$

$$t = 13.09$$

According to analysis test of significance, the calculated value was 13.09, which is greater than the *t*-value from the *t* - dependent sample table, but it was found that $df = n - 1$ was equal to 19, so the alpha value of .05 was chosen, which is equal to 1.73, It was found that the mean scores of pre-test and post-test exams were significantly different at .05. The mean after-test scores were 40.85, which was higher than the pre-test scores of 28.45. Learned with an electric circuit and damages analysis test of air conditioning failures. To be used in teaching and learning in conjunction with experimental worksheet, learners have a greater understanding.

Table 6 The comparison of sample achievement scores between pre-learning and post-learning class group using electrical circuit test kits and damages analysis of air conditioning.

Sample groups	N	$\bar{X}$	S.D.	t-test	Sig.
Pre-learning	20	28.45	3.85	13.09	0.00
Post-learning	20	40.85	0.85		
*p-value=.05					

Table 6, It was found that results of analysis the achievement of learners studying with test kits in combination with the developed experimental worksheets produced statistically significantly higher post-learning achievement than pre-learning at .05 level and had a sig. = 0.00.

The results of evaluation in assessment test to experimental kit with test certificate and questionnaires on study using electrical circuit test kit and damages analysis of air conditioner.

The evaluation use of electrical circuit test kits and damages analysis of air conditioning based on opinions of sample presented as information in terms of overview opinions on electrical circuit test kits and damages analysis of air conditioning and opinions on subject to experimental worksheets.

Table 7 Averages, standard deviations, and levels of user opinions of electrical circuit test kits and damages analysis of air conditioner in overview.

Topics	levels	
	$\bar{X}$	S.D.
1. Teaching & Learning.	4.48	0.47
2. Experimental worksheet.	4.59	0.44
3. Electrical circuit test kits and damages analysis of air conditioner.	4.62	0.44
Total	4.56	0.45

Table 6, it was found that opinions users of electrical circuit test kit and damages analysis of air conditioner as whole were at a highly agreeable level ($\bar{X}$ = 4.56, S.D. = 0.45). The highest is electrical circuit test kits and damages analysis of air conditioner ($\bar{X}$ = 4.62 , S.D. = 0.44), followed by experimental worksheet ($\bar{X}$ = 4.59 , S.D. = 0.44) and aspect with the lowest mean was teaching & learning ($\bar{X}$ = 4.48 , S.D. = 0.47), respectively.

Conclusions

The according to results of experiment, the study electrical circuit test kits and damages analysis of air conditioning can be used to effectively conduct instructional arrangements in conjunction with the experimental worksheet at effectively at 81.90/81.70 was higher than the 80/80 threshold set by average post-test sample achievement of .05, and use of electrical circuit test kits and damages analysis of air conditioning were evaluated

based on sample group. It was found that overall, there was a strong consensus, particularly on the electrical circuit test kits and damages analysis of air conditioning and experimental worksheet. The learners can apply their knowledge and skills to electrical circuits and analyses of air conditioning very well.

Suggestion

1) Using Study Electrical Circuit Test Kits and Damages Analysis of Air Conditioning in teaching and learning, instructors must distribute experimental worksheets for students to study in advance so that learners can know how to use them.

2) Number of students per experimental set Will be in the ratio of 3 students / 1 experimental set to facilitate experiments and help students to be able to perform tasks thoroughly

References

Asma Abdulrahman., & Nami Alshaikh. (2022). The Reality of Using Virtual Labs in Teaching Advanced Biology Curricula in Developing Higher-Order Thinking Skills(HOTS) among Female Teachers at Secondary Level in Al-Kharj.*Education Research International*, 2022(8605202), pp. 12.

Pornthana Juajarn. (2018). Developing academic achievement using skill sets On the use of keyboard shortcuts in Microsoft Word 2016 for students of the 3rd year of vocational certificate (vocational certificate) in the field of marketing. Attawit Commercial Technology College, *Attawit Commercial Technology College*.

Mhamed Ben Ouahi., Mohamed Ait Hou., Abdesselam Bliya., Taoufik Hassouni., & El Mehdi Al Ibrahmi. (2021). The Effect of Using Computer Simulation on Students Performance in Teaching and Learning Physics: Are There Any Gender and Area Gaps. *Education Research International,* 2021(6646017), pp. 10.

Wipada Wongsuriya, Pattanapong Sinpaitoon & Peerapong chanhom. (2020). The development of electrical circuit training package of split type Air conditioning on refrigeration and air conditioning. *Journal of Industrial Education,* 19(1), pp. 68 – 74,.

Asada Wannakayont, Nikom Lonkuntosh & Teangtum Sittichantasen et al. (2019). Development of a training kit for electrical circuit connection in air conditioner**.** *Journal of Graduate Studies Valaya Alongkorn Rajabhat University.* 13(3), pp. 163 – 178.

Puchong Chanjira (2011). A Construction and Efficiency Validation of Electrical Circuit Laboratory Package on Split Air – Conditioning, Master of Science in Industrial Education. *King Mongkut's University of Technology Thonburi. Bangkok*.

Somjai Intanont Pinyo Saisrikaew & Panumet Suksrisiriwat. (2015). The skill of Instruction media for Lightingciruit. *Industrial Technology Journal,* 1(1), pp. 81 – 88.

JegeleviČius, D. Pagodinas, D. & Dumbrava, V. (2010). Laboratory Experiments in Circuit Theory: Link between Theoretical Concepts and Practical Examples. *Electronics and electrical engineering,* 102(6), pp. 107 – 110,

Chusak Plianphu. (2008). Principles of teaching industrial technicians, principles of teaching in practice,*Bangkok: Edison Press Products*.

Ely Donald, P. (1972). Visual Materials of Instruction. Chicago. *University of Chicago*.

Dale & Edgar. (1969). Audio Visual Method in Teaching. *New York: Holt Rinehart and Winston Inc.*

Shah, B. Dwivedi, S. & Singhal, A. (2019). Energy saving in split air conditioner using evaporative cooling pad at the ODU. *Int. J. Innov. Technol. Explor. Eng.*, 9(1), pp. 1858–1862.

Somsak Sumotayakul. (2016). Refrigeration and air conditioning, se – education public company limited.

Thiraphong Borirak & Pongsawat Kochapoom.(2013). Efficiency Enhancement for Split Type Air Conditioning Systems by Decreasing Condensing Unit Temperature. *EAU Heritage Journal Science and Technology*, 7(2), pp. 57 - 64.

Thawika Phatidamrongkul Jatuwat Varodompun. (2012). Field Efficiency of Split-Type Air Conditioners with Evaporative-Cooled Condensers.

Phatidamrongkul, Thawika, & Jatuwat Varodompun. (2012). Field Efficiency of Split-Type Air Conditioners with Evaporative-Cooled Condensers. *Journal of Architectural/Planning Research and Studies (JARS)*, l 9(1), pp. 101 – 112.