

Developing a Smart Window Air Conditioner Training Kit for Vocational Students: An Effective Teaching Kit

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Abstract Skilled labor is critical to create a high-income economy, and it can be done by providing a quality teaching in Technical and Vocational Education and Training (TVET) institutions. TVET includes not only abstract skills but also, most notably, practical skills, particularly for vocational students. In addition, students will also be qualified to be excellent at soft and interpersonal skills. Teaching practical skills is also a challenge for most trainers. Content knowledge is essential to support the practical training delivery. Therefore, teaching aids are found to be a practical solution to assist trainers to teach practical lesson. This paper focuses on the development of the Smart Window Air Conditioner Training Kit. It was designed and developed based on Analysis Design Develop Implement Evaluate (ADDIE) model which encompasses Analysis, Design, Develop, Implement and Evaluate. The kit has been evaluated and tested based on its design, functionality and practicality to be used in laboratory. The findings indicate that all five experts have agreed on the usability of this kit as a teaching aid for Heating, Ventilation and Air Conditioning (HVAC) subject. Finally, 20 vocational students have been used to experience the training kit in their training session. The dimension of intention to use the training kit among respondents had been measured with $M=4.48$ ($SD=0.53$) which concludes that the student's intention to use this kit is high. This kit is important to HVAC program particularly in Installing, Servicing, Troubleshooting and Repairing Window Type Air conditioner.

Keywords TVET, Teaching Aid, HVAC, Smart Window Air Conditioner

1. Introduction

Growth and change in vocational education highlight the acquisition of skills as one of the priorities for a semi-skilled and skilled workforce to be born. The enthusiasm in producing a semi-skilled and skilled workforce is reflected in the emergence of new skills programs such as Vocational Basic Education as well as the transformation of Technical Secondary Schools into Vocational Colleges introduced by the Ministry of Education (Hashim, & Ahmad, 2007). This requires the development and changes in the student's skills were equally instrumental in developing the potential to compete with mainstream education. Students should master the principles and knowledge in the area of practical skills involved. These elements are essential in producing a competent and skilled workforce that is capable of keeping up with the ever-changing technological advancement. Self-confidence, knowledge and boldness in practical activities should be placed at the top of priority in producing students who are competitive and thus create a skilled workforce.

It is important to increase students' confidence,

understanding and skills in a particular topic through extensive training as a result from practical activities. Exposure to the actual work situations is essential to equip students with particular skills and confidence (Aishah, 2006). Practical activities that are conducted in a conducive environment can attract students, increase students' confidence and enhance their creativity so that they will not feel awkward and will be more confidence when they encounter the same situation while in the actual workplace environment. Therefore, it is important to embed and apply an actual material during teaching and training, to make student familiar with actual work process. It is within the classroom context, the best we can provide is the training kit as a teaching aid.

The use of supporting materials such as Teaching Aids should be provided to obtain the perfect stimulus of response (Abbas, 2006). Every teaching and learning process should use Teaching Aids. The usage of Teaching Aids allows students to experience the learning activity and helps facilitate student's understanding. The use of Teaching Aids also greatly influences students' interest and willingness to actively participate in the teaching and learning process. However, there are various barriers which have made lecturers or teachers contemplate to use Teaching Aids in the teaching and learning process (Aris, 2000). The use of Teaching Aids in the teaching and learning process can attract students' interest in mastering a topic. Additionally, teaching and learning process using a variety of Teaching Aids can create excitement (Ahmad Hassan, 2004). Meanwhile, attractive Teaching Aids eliminates boredom and enhances students' engagement in teaching and learning process. Therefore, the goal of this project was to design a Smart Window Air Conditioner Training Kit for Level 2 HVAC in Vocational Basic Education (PAV). It will help to provide students with a better understanding of the wiring systems and the window-type air-conditioner charging functions.

1.1. Teaching Approach

Inductive approaches involve teaching that starts with specific things and then moves toward a comprehensive conclusion (Eggen and Kauchak, 1988). The introduction of a topic begins with specific examples and then other examples that teachers and students provide. This way, students can be actively involved in learning and increase the level of their understanding. A conclusion is made at the end of the lesson on the topic that has been covered.

A mastery approach is teaching that provides a learning environment once a student has mastered a skill, moving on to a new skill (Guskey, 1997). In this approach, students who are yet to master the skills are given intensive activities as knowledge strengthening. Teachers will begin teaching or introduce a new skill once they have mastered the previous skills. But the teaching method practiced by almost all Asian nations is teacher-centered rather than

student-centered, without any flexibility in mastering the skills (Neetha, Nandini, & Padmanabha, 2019).

Teacher-centered teaching is a method where teachers play an active role while students listen and accept (Ismail, Nasir, Hassan and Masek, 2015). Teacher needs to be attractive and interesting to student in class (Masek, Hashim, & Ismail, 2019). The teacher-student relationship that occurs is commonly one-way. Students become more passive by simply listening and answering questions posed by teachers. Among the teaching methods are lectures and demonstrations. Student-centered teaching is one that involves students playing an active role in learning. Not only students listen and copy, but they also engage in various activities such as problem solving, drawing and discussion. The two-way interaction between teachers and students will create a conducive atmosphere in learning.

Material-centered activities are the basic ingredients of most teaching methods; thus, the learners' involvement and creativity are totally ignored (Nazir, Jano, Omar, & Kamarudin, 2019). Material-centered teaching application, in turn, focuses on students' use of learning materials. Student-centered integration of learning resources, as students do not need to proactively look for items, rather than benefit from their availability in different contexts (Christian & Steffen, 2019).

Students interact with the material to understand and master a particular skill or topic, while teacher is more than a guide (Aishah, 2006). Learning materials may contain Teaching aids, modules, workbooks and more. Students engage more with learning materials than they do with teachers. This will activate the class hours and improve their information transfer.

1.2. Teaching Aids

Teaching Aids is a tool or material that teachers use to assist them in their teaching and learning. Teaching aids were tangible artifacts because they were real and meaningful in enabling students to interact and visualize, thereby attracting the attention of the students (Nachiappan *et al.*, 2018). The main task of Teaching Aids is to assist teachers in the delivery of teaching content to students (Nor, 1994). The use of Teaching Aids does not only include textbooks, modules, whiteboards, videos, and pictures, but it also includes anything that students can see and use. Teaching Aids is something students can experience (Abbas, 2006). The use of Teaching Aids can not only stimulate student interest but also provide opportunities for students to use these tools as new skills and experiences (Abbas, 2006). While the use of Teaching Aids attract students and impart new skills, it should be wise for the teacher to choose and customize the use of Teaching Aids with teaching contents to be delivered.

Previous study has well documented on the importance of teaching aids, for instance, Abbas (2006) mentioned that teaching aids provide stimulation and interest to students;

provide a solid foundation for the development of students' understanding and thinking patterns, and reduce unwanted verbal responses from students; provide developmental policies learning and making learning more permanent; provide new experiences that cannot be easily obtained by other means and make learning more immersive and diverse; and enhance understanding and increase vocabulary development. Mok (2003), on the other hand, emphasized the importance of Teaching Aids such as: (i) helping teachers present their lessons accurately; (ii) stimulating students' interest in focusing on lessons; (iii) facilitating teachers' delivery of their lessons; (iv) using Teaching Aids such as models, without having to write information on the blackboard; (v) enabling students to associate concrete objects with abstract facts; (vi) helping students strengthen their memory; (vii) helping students engage in styling or recovery activities; (viii) enabling students to conduct research, through project or research-discovery methods, and draw conclusions using Teaching Aids; and (ix) helping students solve their own problems using Teaching Aids.

Many studies have shown the importance of each of the teaching aids in improving learning as well as the factors influencing its use (El Batri, Alami, Zaki, Nafidi, & Chenfour, 2019). Active and effective learning requires the use of several teaching aids (Unesco, 2016). This includes online, technology and internet support (Zainal Abiddin and Ismail, 2014). Therefore, the use of active learning methods and the diversity of teaching aids in a science course are indicated by effective learning. On the other hand, the excessive use of dogmatic methods (student passivity) accompanied by a single teaching aid (the textbook) constitute indicators of less effective learning, especially when it adds to the effect of the high number of students per class (El Batri, Alami, Zaki, Nafidi, & Chenfour, 2019).

1.3. Window Air Conditioning

There are various types of air conditioning used for learning in the field of cooling and air conditioning whether domestic or commercial (York, 2007). For skill institutions, students can participate in the Malaysia Skill Certificate (MSC) program, such as the regular daily schools offering Basic Vocational Education (BVE) programs in this field, the syllabus used is named as National Occupational Skill Standard (NOSS), developed by the Department of Skill Development (DSD). The National Occupational Skill Standard (NOSS) used for this BVE program is called ME-020-2: 2012, HVAC (Heating, ventilation and air-conditioning) domestic level 2.

There are two types of air conditioning studied in this NOSS: i) air-conditioned; and ii) air-conditioned windows. The research done in this project is related to window type air conditioning. Although the target audience are regular school teachers and students who enroll for BVE field

programs, they can also be used in other institutions that use the same NOSS and other institutions that offer similar fields (York, 2007). The type of air conditioning used for the project was from the York brand, the YWD10C-AA model. The choice of this brand is due to the existing facilities factors at the institute.

2. Methodology

There are various models that can be used to create a design. The production of a design can adapt one or a combination of any models. The model used in this project is the ADDIE Model. The main goal of this project was to design and develop a teaching aid for students and teachers to use in regular daily schools as well as in other skill centers such as Vocational Colleges and Community Colleges in the field of Refrigeration and Air Conditioning.

2.1. Research Population and Instrument

A set of questionnaires was employed to three (3) experts in Heating, Ventilation and Air Conditioning (HVAC) that have industrial experience and more than 10 years teaching experience and two (2) experts in teaching in the field of HVAC. The research instrument which is a set of questionnaires was administered to the experts to analyse the functionality and usability of the teaching aid. Final product was tested to 20 students to examine their intention of use.

2.2. Development Model

There are five phases in ADDIE model namely planning phase, design phase, implementation phase and testing phase. During the planning phase, the researcher made the decision to use existing facilities and tools at the institute. This is to facilitate the development of the Smart Window Air Conditioner Training Kit. The type of air conditioning used by the York brand is one horsepower (York, 2007) as in Figure 1.



Figure 1. Air conditioner York Window Type

In the design phase, this kit is designed to fully operate like a real window air conditioner without changing the original component's position while also functioning as a good Teaching Aids. To accomplish this purpose, researcher has identified three key areas that need to be designed.

In the implementation phase, all of the planned designs are implemented. There are 5 parts implemented during this implementation phase. These areas include materials collection, component separation, construction equipment, PPE and development.

The final phase is the testing phase in which all components are properly positioned including plumbing and wiring parts. The system is tested to evaluate the results of the functionality. Assessment is the most important phase in determining whether this kit is a good Teaching Aids. In achieving the objectives, the assessment is conducted using questionnaires and interviews with experts in the field of cooling and air conditioning. The results of the assessment from these experts have enabled researchers to make improvements. Assessments were made after this kit is fully developed.

2.3. Product Design

During this phase, this Smart Window Air Conditioner Kit was developed. The development of this kit was made after all the materials and equipment involved were identified. The development process was carefully followed to obtain an accurate measurement, strong welding and neat wire connections to ensure the safety and security of the Training Kit. The work steps undertaken in this phase are as follows:

(a) Framework development

The first step in the development phase began with the design of this Window Air Conditioning Kit. Figure 2 displays the isometric framework design of the kit.

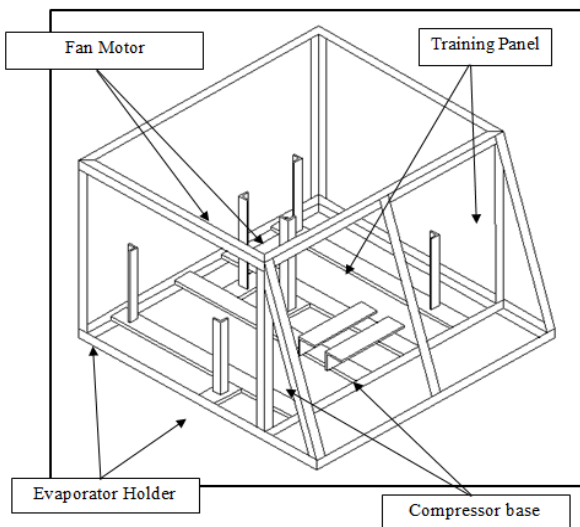


Figure 2. Isometric framework design

The frame size is 2 feet x 2x x 13in. The materials used to develop the framework are 1.5 inches' x 3 mm angular iron and 2 inches' x 5 mm flat iron. The Air Conditioning Training Kit Frame is welded using a 2.5 mm arc type and rod welding as in Figure 3.



Figure 3. Welding Process

The second process is the packaging process. The welded frame was painted and sprayed with clear spray as in Figure 4. A piece of plywood was used to cover the base of the skeleton and a layer of rubber was placed on the plywood to cover the defects and impact of the plywood cut.



Figure 4. Finishing Model

(b) Installation of components

Two processes were carried out for component installation, namely installing components and welding copper pipe. The components involved are the compressor, condenser, evaporator, fan motor and fan blade mounted on the component holder's leg. Installation of components was made on component holder using self-drilling screw.

The process of connecting the copper pipe was done using a gas welding set and using the silfosing method. In addition to the copper pipe connectors that connect each component of the air conditioning, the connectors also include additional plumbing that connects the air-conditioning system with pressure gauges and service valves.

(c) Fuel drainage installation

To give a true picture of how the evaporated water from the evaporator to the actual window air conditioner is drained out, a channel was designed. The material used is a 1.5-inch x 2-inch wiring case and a 0.5-inch pvc tank connector. This evaporator design uses the same concept as the original window air conditioner and evaporated water is pumped out through high-pressure sections. This drainage system was affixed to the skeleton using double-sided tape.

(d) Installation of training panels

The training panel located on the right side of the Window Air Training Kit was divided into two parts, the

electrical part used for the wiring training and the mechanical part used for the service of the cooling service. This training panel uses 6 mm thick acrylic as a face board. On the electrical side, the actual component symbols were drawn, all the original wiring would be connected to the symbol through the back of the panel. Figure 5 demonstrates the Electrical Wiring Schematic Circuit for the kit.

This connection allows for wiring training using separate wires. The fan speed adjusters, thermostat adjusters and louver switches were placed on the wiring training panel. Figure 6 illustrates the design for electrical and mechanical training panel.

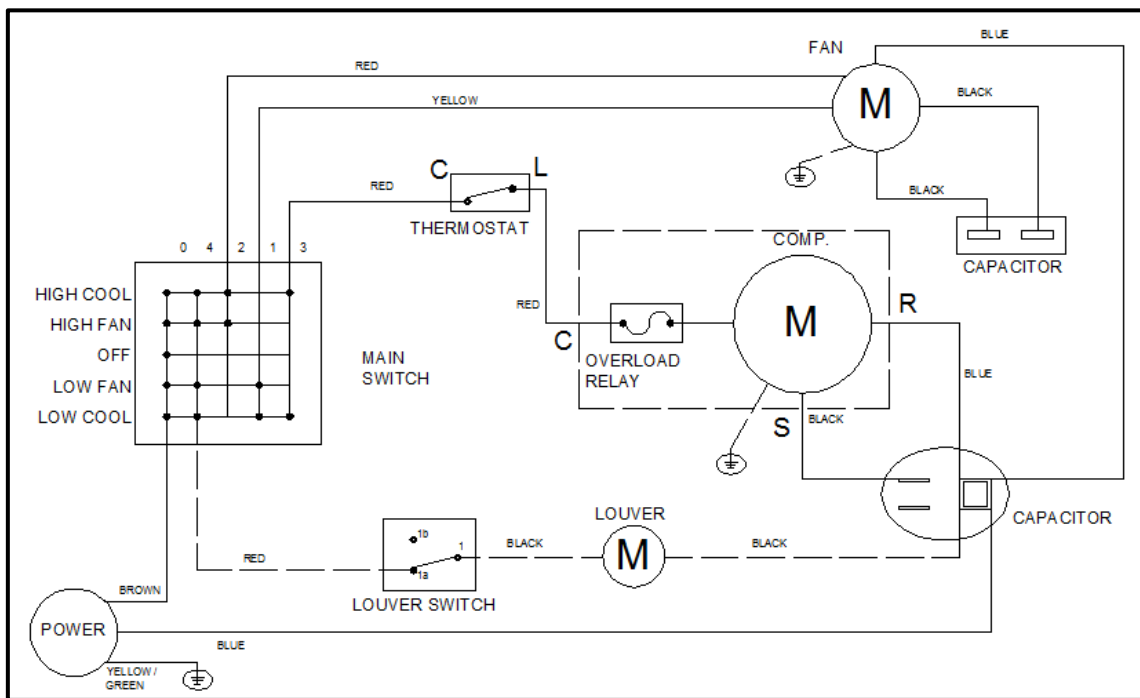


Figure 5. Electrical Wiring Schematic Circuit

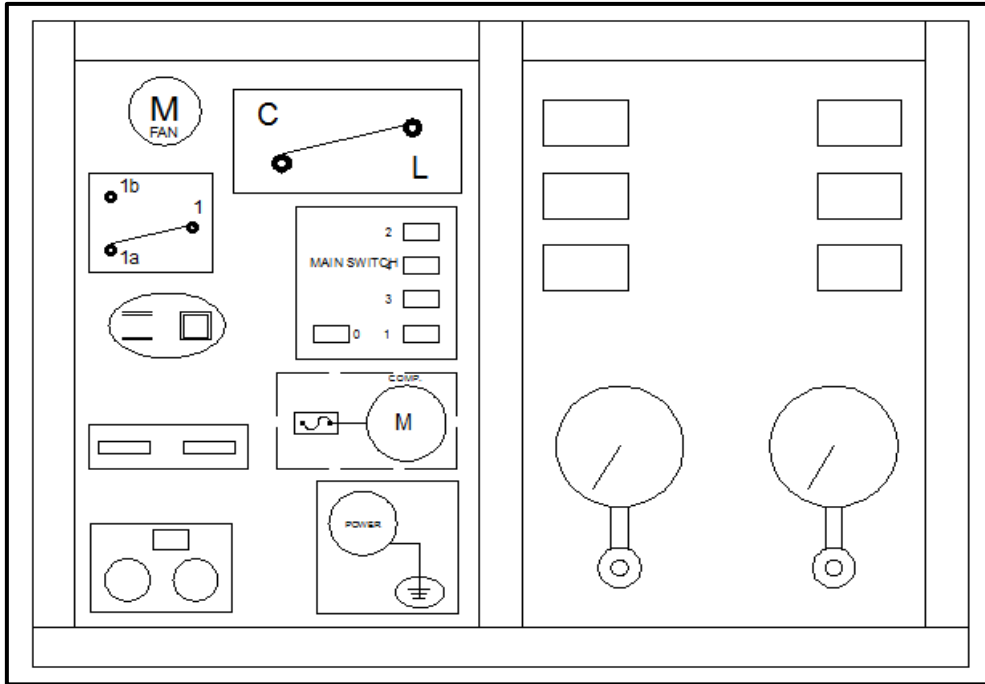


Figure 6. Electrical and mechanical training panel

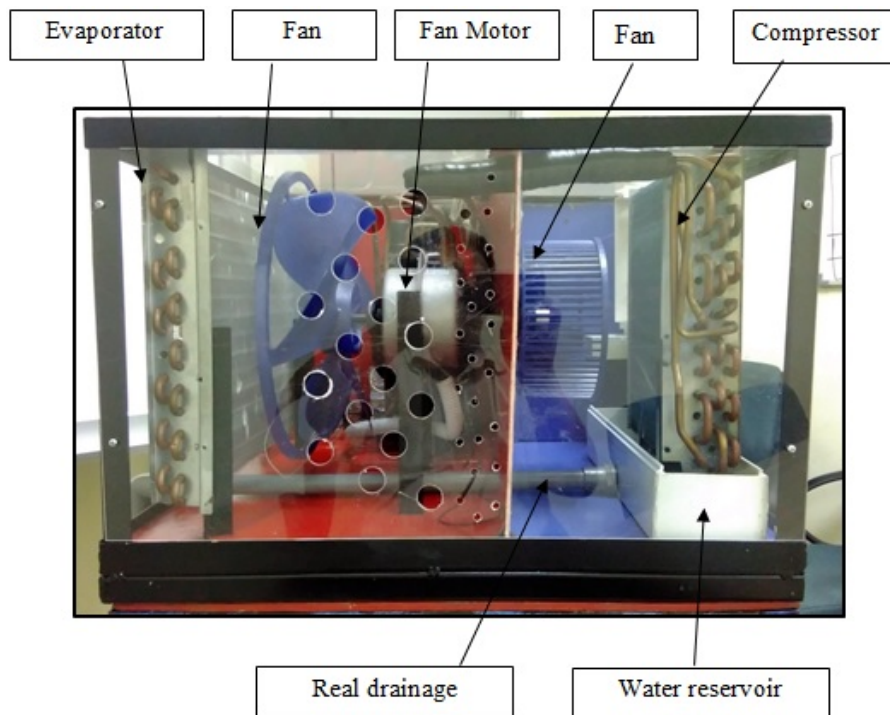


Figure 7. Final Product

On the mechanical side are six digital thermometers, two pressure gauges and two servo valves. Three thermometers were connected to the low-pressure section of the system to obtain readings of the air inlet of the evaporator, the evaporator temperature and the air temperature of the evaporator. The other three thermometers were connected to the high-pressure section allowing readings of the

condenser air temperature, condenser temperature and exit air temperature of the condenser. Two gauges for low pressure and high pressure were placed on the panel for low-pressure readings and high-pressure systems. Modification of the original copper pipe was performed to allow this pressure gauge to be installed. Two service valves mounted on the panel are low-pressure valves and

high-pressure valves mounted on the panel were connected to the low pressure and high-pressure portions of the system. These pressure valves are used for cooling service. Pressure gauges and pressure valves were connected using an oxygen-fixing weld set and using a silfosing method.

(e) Installation of frame cover

The final step in this development phase is to install the window cover of the Air Conditioning Training Kit. The material used is 6 mm thick transparent acrylic, the choice of this transparent acrylic as a cover for the purpose of making all the components of the windows air-conditioned and the drainage easy to see. The final product can be seen in Figure 7.

3. Testing Phase

Testing is an important process for determining which training kit to be able to operate as planned. During this phase, the completed Window Air Training Kit tested its operation to ensure that all mechanical and electrical components were working properly. Testing is also done for the practical work activities that can be done in this training kit. Data analysis was done based on the data obtained from the questionnaire distributed to the experts. The analysis was conducted to ensure that the research questions were answered. Five respondents which are experienced experts were involved in this project.

3.1. Design Analysis

The data obtained through analysis are shown in Table 1.

Table 1. Training kit design analysis

NO.	ITEM	YES		NO	
		Num.	%	Num.	%
1	Kit design is mobile.	5	100	0	0
2	Kit design is safe to use.	5	100	0	0
3	It's easy to see parts of each set.	5	100	0	0
4	Durable and sturdy kit design.	5	100	0	0
5	The size of this kit is suitable.	5	100	0	0

The analysis results in Table 1 show all respondents agreed with the design of Smart Window Air Conditioner Training Kit which concludes that it is portable, safe to use, easy to see, durable and strong and fit.

3.2. Training Kit Functionality Analysis as Teaching Aids

An analysis of the functionality of the training kit was conducted to achieve the objectives of this study. Table 2 shows the analysis data obtained through the questionnaire form completed by the experts.

Table 2. Training kit functionality analysis as Teaching Aids

NO	ITEM	YES		NO	
		Num.	%	Num.	%
1	This kit is ideal for use during the teaching and learning process.	5	100	0	0
2	This kit can improve student understanding.	5	100	0	0
3	This kit can create a two-way teaching and learning process.	5	100	0	0
4	This kit can attract students' interest.	5	100	0	0
5	This kit can help teachers effectively deliver the content.	5	100	0	0
6	This kit can diversify the way teachers teach in the classroom.	5	100	0	0
7	This kit promotes the use of student's senses during the teaching and learning process.	5	100	0	0
8	This kit has an interesting design.	5	100	0	0

The analysis results in Table 2 show all respondents agreed with the items evaluated, based on the feedback of the respondents, this Smart Window Air Conditioner Training Kit works as a good Teaching Aids.

3.3. Training Kit Suitability in Laboratory

Table 3. Training kit suitability in laboratory

NO	ITEM	YES		NO	
		Num.	%	Num.	%
1	This kit is easy to operate.	5	100	0	0
2	This kit saves space.	5	100	0	0
3	This kit is safe to use in practical work.	5	100	0	0
4	This kit is suitable for student's learning.	5	100	0	0
5	This kit represents the real device.	5	100	0	0

Table 3 shows the item analysis to evaluate the suitability of this Smart Window Air Conditioner Training Kit in the laboratory room. According to the table, all respondents agreed that the training kit was easy to operate, save space and was safe to use during practical work.

3.4. Materials/Components and Cost Analysis

The production of this training kit involves materials and components that are readily available in the market. The costs involved in producing this training kit are also reasonable. List the size/quantity of materials/components and the cost expenses in Table 4.

The total cost for this project is RM1303. Nevertheless, this expense will only be incurred once and the institute will use this package several times without having to purchase new equipment. This saves thousands of ringgits and helps hundreds of students.

Table 4. Materials/components and cost analysis

No.	Materials / Components	Measurement	Quantity	Cost (RM)	Amount (RM)
1	York 1HP window air conditioning	-	1	750.00	750.00
2	Inlet valve	-	2	7.00	14.00
3	Pressure gauge	-	2	80.00	160.00
4	¼" x 0.61mm copper pipe	1 metre	1	30.00	30.00
5	¼" flare nut	-	2	3.00	6.00
6	Digital thermometer	-	6	15.00	90.00
7	Flexible pipe	1 metre	-	4.00	4.00
8	Angular iron 1¼"	3 metres	-	15.00	15.00
9	Angular iron ½"	3 metres	-	12.00	12.00
10	Hollow iron 1" x 2"	2 metres	-	15.00	15.00
11	Flat iron 4mm x 1½"	2 metres	-	18.00	18.00
12	Plywood 6mm	2 metres	-	5.00	5.00
13	Wood filler	-	1 tin	14.00	14.00
14	Paint	-	5 tin	10.00	50.00
15	Acrylic	2 metres	1	120.00	120.00
Overall total					1303.00

4. Implementation Phase

Table 5 explains the intention of use among 20 vocational students based on their experience in using this kit during their session. The overall mean for intention to use the Smart Window Air Conditioner Training Kit is $M=4.48$ ($SD=0.53$). This is considered a high intention of use which describes the acceptance of this kit among vocational students.

Table 5. Intention to Use

No	Item	Mean	Standard Deviation
1	I tend to use Smart Window Air Conditioner Training Kit in my class.	4.53	0.34
2	I increase the occurrences of using Smart Window Air Conditioner Training Kit in class.	4.24	0.45
3	Using Smart Window Air Conditioner Training Kit in my class to enhance students' learning interest.	4.62	0.64
4	I'd love to use Smart Window Air Conditioner Training Kit in my class.	4.76	0.33
5	I use Smart Window Air Conditioner Training Kit to provide multi-approaches on teaching.	4.25	0.54

5. Discussion

Abbas (2006) stated that Teaching Aids can not only

stimulate student interest but also provides opportunities for students to use these tools as new skills and experiences. Nachiappan *et al.*, (2018) stated that Teaching aids are developed by teachers in line with the objectives of the lesson provided by the national standard syllabus, according to their creativity. Furthermore, Teaching Aids are certain devices, tools, and things the instructor uses to help students understand the lesson concepts (Alshatri, Wakil, Jamal, & Bakhtyar, 2019). The design of the Smart Window Air Conditioner Kit should be able to meet the characteristics of Teaching Aid. The size of this training kit compared to the actual air conditioner provides space for the components involved to be rearranged. The position of the components in this training kit is incomparable and as true as the actual air conditioner.

This Smart Window Air Conditioner Training Kit can be moved from one place to another; thus, a strong and intricate mount is required. For this training kit design, the researcher used a combination of hollow iron, angled iron and flat iron to make sure it is heavier than the actual air conditioner. However, further study and design need to focus on the high technology kit and the integration of ICT in the teaching kit. Neumann and Waight (2019) highlight the rapid advancements in instructional technologies in the past decade, as well as the pressing need for educators to research how "21st century cutting-edge technologies" have been/can be applied to the teaching and learning of science. All technologies that rely on massive data collected about learners' choices and actions allow the technology-rich environments to provide personalized real-time feedback (Oliveira *et al.*, 2019).

In general, the results of the research show that this Smart Window Air Conditioner Training Kit can function as an effective Teaching Aid. Teachers also need to understand and have high competency in delivering teaching and learning activity (Ismail, Hassan, Masek, Hamzah, Ismail, and Subramaniam, 2016). The operation and positioning of its components based on the actual air conditioner can give students a clearer picture and understanding. Training panels for the purpose of electrical and mechanical work training provide the necessary skills before working on a real air conditioner. The addition of a thermometer to indicate the temperature difference between the low and high-pressure sections can account for theory and practical learning.

6. Conclusions

This Smart Window Air Conditioner Training Kit was successfully developed and functions very well in terms of its functionality and usability. It is also easy to operate and has good safety features to reduce the risk of accidents during the teaching and learning process. It is hoped that with this Smart Window Air Conditioner Training Kit will assist the educators in the field of cooling and air conditioning. They will be able to implement the teaching and learning process more effectively and improve students' understanding and mastery learning. By using this training kit, TVET institutions can cut costs on training without neglecting the basic requirement of training activities. The variety of activities in one Teaching Aid makes the teaching and learning process more effective. However, further study needs to be conducted to investigate the impact of this kit on the student's cognitive and psychomotor achievement. As a conclusion, teachers should be creative and innovative in their teaching to ensure the quality of teaching delivery thus increase students' engagement in class.

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