Educational Robotic Trainer: An Interactive Tool to Transfer of Knowledge

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Abstract *–The study was conducted to design and develop a prototype of an educational robotic trainer as a tool to improve the teaching-learning outcomes of students enrolled in engineering and other related technology courses. The trainer determined the effectiveness of students' learning outcomes. It also determined the trainer's level of acceptability as evaluated by experts. The study made use of product development and quasi-experimental two-group pretest and posttest methods using a questionnaire carefully chosen and sorted from various standard questionnaires. The study was conducted among 32 4th year and 5th year college students and 19 experts from a state college in the Philippines. Results showed that the prototype of the educational robotic trainer made a major impact in improving the proficiency level of the students in terms of teaching-learning outcomes. The trainer helped the students to be more innovative and creative. Students were more enthusiastic in performing their practical and laboratory activities. The trainer has a wide range of applications and very versatile.* Similarly, t*he trainer serves as a good teaching aid thus facilitate better assimilation of knowledge through practical and laboratory activities and other skills development.*

Keywords–*Learning outcomes, product development, transfer of learning, creativity, educational robotic trainer.*

INTRODUCTION

The dearth of facilities and machines used for learning simulations in highly specialized and technical field of engineering is a major issue. This hampers the learning process and development of the students. Thus, higher educational institutions in the Philippines look at this as a major challenge to encourage educators to look for solutions to this issue.

Further, the 1987 Philippines Constitution as stipulated in article XIV Section 1 [1], profoundly stresses the promotion and protection of the right to quality education of all citizen at all levels subsequently provide the necessary steps to make it accessible to all. Educators are expected to be well equipped, trained, and innovative to be able adapt to the needs of the learners. Inherent to their jobs, however, is their academic freedom i.e. the option to choose and adopt varied teaching strategies which are suitable to their objective [2]. The integration of various learning modalities in teaching should be promoted in the classrooms. Amongst educators, it is a common notion that integrating the use of technology enhances the learning process. Thus, to provide a quality education, it is expected that teachers must use educational technologies and these must be taught to students [3].

The limiting factor is due to the difficulty in defining and measuring the improved learning outcomes as learning technology is used in the classroom [3]. Nonetheless as describe by Parr [4], students' perceptions influence the success of integration, specifically the amount of technology use, the ways in which the technology was used, and teachers' and students' expectations about learning. The quality of students' learning outcome depends on how systematic the teachers' and students' perception are associated.

Though it is true that perceptions of learning from both student and teachers side is important, yet, experienced teachers with limited professional development and inappropriate perception of learning technologies tend not to use the learning technologies in the classroom [5]. Relatively, most teachers perceive that teachers' readiness or enthusiasm for technology implementation helps students improve are considered as learner-oriented learning environments where students' self-directed and independent learning increases as they are responsible for their work and manages their learning on their own pace [6].

These directed learning strategies have come up with the application of educational robotics. Robotic activities used as intervening factors to translate the teaching-learning activity into more interpretative and real time actions. It is specifically designed to propel learners to discover technology through hands-on, building, assembly, and design nowadays called modular/project-based teaching approach. It is the collaborative effort between the learners and the teachers that affect the teaching-learning process.

Now that learning process is more student-centered, the importance of increased autonomy of the learner groups rather than the teachers' over-participation in the teaching-learning process is highly encouraged. This led to a new learning environment trainer that relies on the cooperation between the learner groups, the teacher and the computer-based interactive learning systems. Robotic activities help learners discover technology by exposing them to actual handling, designing, and driving robots through a project based approach. [7]

The learning can be more intensified when learners are exposed to project-based learning or project pedagogy. Learners further gain wider understanding of classroom content when they have hands-on environment experience that exposes them to a more challenging and problem solving opportunities [8]. This increases their ability to collaborate, make engagement and linkages, and self-manage while honing their problem solving and critical thinking skills.

Educational robotics provides a potential avenue as learning and teaching tool, which allows integrated and multi-disciplinary approaches both for technical and social topics. This builds mental connectivity and associations along varied fields covering engineering, physics, and mechanical concept [9].

This is just a few learning environments offered by educational robotics of learners' adaptation to new technologies which motivates them to look for new approaches and techniques in solving problems.

As pointed by another study, giving importance in the relationship between epistemological beliefs and approaches provides a clear manifestation of the latter's influence in the performance of the students. Thus, a classroom becomes a place full of real experiences that would result to creation of new ideas which later be converted to technological or scientific advancement [10]. The nature of knowledge added by constructivist approach has changed the learning paradigm of students.

Developments of different instructional media such as interactive computer simulators, long distance learning, and modular approaches focus mainly on the cognitive and affective domains, but less on the psychomotor. To have quality learning outcomes, a well-balanced integration of these three domains should be observed. These can only be attained through proper exposure to actual and practical environments. These approaches have deepened the mindset of the learners thus critical thinking is highly developed.

As explained by Baylon [11], critical thinking is a lifelong skill when fully developed will allow students to see the real context. Teachers must introduce varied learning approaches to inspire students to actively participate so they may ask questions along the different level of critical thinking. Students manifest their acquisition of critical thinking skills if questions they formulated fall along these different levels [11].

In Electronics Engineering, these critical thinking skills as stipulated in the 21st century skills are given more emphasis. Actual hands-on activities form part of the educational approaches so students are exposed to wider latitude of learning opportunities. This is strengthened by Papert and Idit Harel [12], when learning-by-making approach was introduced. The learner internalizes and constructs new knowledge based on past experiences and encourages processing higher level skills, which allows them to make significant connections and solve complex problems.

By joining creative and critical thinking together through problem-based learning; learners developed multiple learning skills [13]. Students' creativity is indicated when they provide different possible solutions. These solutions looking at it without prejudice and processed reasonably and analytically manifest critical thinking. Hence, learners participate actively to create innovative solutions to the problem based on their experiences.

These learning experiences are maximized, if indeed educators were able to transfer the learning as desired. To facilitate transfer of learning, once the information and strategies where introduced and practiced, educators must prudently plan when and where it will be applied [14]. This approach will help the students maximize the possibility of applying what they learned in today's class and make use of that learning for the future.

To reinforce the transfer of learning, Edgar Dale's Cone of Experience was employed to effect learning by applying real and hands-on learning experiences simulating "doing the real thing" [15]. Perceptions and interpretation of information can be more reinforced not only with the aid of aural and visual manifestation but with actual interaction with things around us. This is why modern approaches are accepted as new ways of teaching style. With this, students seek immediate application of their newly acquired skills and knowledge. The actual hands-on can be done through learning mock-ups that can simulate real scenarios.

Mock-ups can be developed following product development models.

New product development model [16] and evolutionary development [17], provide a logical step-by-step platform that create a comprehensible step-by-step guide for the user to follow in the pursuit of creating a new product to be introduced to the market. Creating new products in the market triggered by creativity [18] being the ability of developing new ideas can be an avenue to improve product development [16]. One's creativity can be transformed into real things through a systematic process resulting to inventions and innovations.

These innovations and inventions has catalyzed the making of the most advanced laboratory equipment. Robotics and Mechatronic laboratories are widely used as means to adapt to the dynamic needs of students to meet the industry standards.

However, in the Philippine setting, the costs of these Mechatronics and robotics laboratories are very expensive, so government schools have difficulty to afford such. Engineering and technology schools are forced to follow the old and conventional way of teaching, in effect, the students are deprived of proper and the necessary skills to meet the fast and changing technology.

The present study addresses the problem of inadequacy of laboratory equipment by developing an educational robotic trainer. This helped provide the much needed but missing provision for robotics and Mechatronics laboratory. The educational robotic trainer was made in such a way that would be capable of accepting various programming software which the students will find easy to adapt.

OBJECTIVES OF THE STUDY

The study was undertaken to design and develop a prototype of an educational robotic trainer that will improve the teaching-learning outcomes. Specifically, the study aims to: 1) design and develop the prototype of an educational robotic trainer; 2) determine how effective the trainer in terms of: a) students' and experts' evaluation, and b) Student's Learning Outcomes; and 3) determine the trainer's level of acceptability as evaluated by experts.

MATERIALS AND METHODS

The method used in this study is new product development since its objective is to make a working prototype of an educational robotic trainer.

Descriptive and quasi-experimental methods were also employed. These were used to identify and evaluate the trainer's acceptability and effectiveness. The study was composed of three stages, namely: the pre-experimental phase, the experimental phase, and post-experimental in evaluating the trainer's acceptability and effectiveness in terms of teaching-learning outcomes.

The product development phase guided the researcher in building the trainer. The first stage of the trainer was planning and ideation. This consisted the preparation of the working drawings and schematics, and the time frame of construction. Estimates and specifications of the needed supplies, materials, tools and equipment as presented in Figure 1.

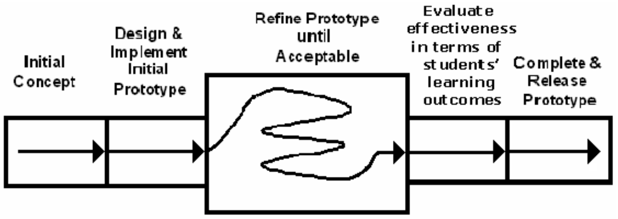


Figure 1. The Conceptual Paradigm (Adapted from McConnell**)**

The second stage is the design, construction, and initial prototyping. In this stage a working trainer was made. The construction of the prototype involves the assembly of the different parts specified in the working drawing, and schematics.

The third stage is the refinement and the revision of the prototype to an acceptable level after all possible testing, try-out, and improvements have been completed. The testing and revision is a cyclic approach utilized to obtain the set product standard output.

The fourth stage is the evaluation of the trainer to determine the learning outcomes as evaluated by experts and students. It also covers the evaluation of the trainer's level of acceptability by experts.

The last stage is the release of the completed educational robotic trainer which was used as mock–up and can be used as model for mass production.

The design, construction, try-out, revision, and evaluation phases the educational robotic trainer were done at the Electronics Laboratory of a State College.

Using purposive sampling technique, 32 electronics engineering students who were passers in the pre-requisite course and are officially enrolled in the industrial electronics course are the student-participants. Each group was composed of 16 students which were sorted using odd – even scheme from highest to lowest where the odd group was the experimental group and even group named as the control group.

By applying the ranking technique in the pre-test conducted; and odd-even scheme from highest to lowest, the researcher determined the composition of the control and experimental groups. Afterwards the pretest scores of the two groups were examined using the T-test to determine their homogeneity and equality. These schemes were used to remove biases in determining the two groups.

Table 1 shows the summary of the T-test computation of the pretest. The data provides a clear manifestation that the students were homogenous.

Table 1. Summarized Data of T-Test Computation of the Pretest

Groups	N	Mean	Std. Dev.	Std. Error Mean	T – c	T - t	Sig. Level (2-tailed)
Control	16	14.81	2.69	0.672	-0.549	1.697	0.593
Experimental	16	15.37	3.18	0.795			

Purposive sampling was also used to determine the 19 expert-collaborators. They were Electronics-Electrical instructors, licensed engineers, and technical practitioners, from different colleges.

A questionnaire was distributed to gather the responses and opinions of the experts and the students regarding the acceptability and effectiveness of the trainer. This questionnaire was formulated based on standard questionnaires [19]. Aside from the questionnaire, the pre-test - posttest and actual hands-on evaluation were also utilized as relevant source to test the effectiveness of the trainer. T-test for comparing means was employed between the post test scores of the experimental and control groups to evaluate the trainer's effectiveness based on learning outcomes. The given Likert scale was used to interpret the result of evaluation: 4.51 – 5.00: Greatly contributed; 3.51 – 4.50: Adequately contributed; 2.51 – 3.50: Fairly Contributed; 1.51 – 2.50: Had little Effect; 1.00 – 1.50: Had no Effect.

Similarly, the acceptability of the trainer based on the experts' evaluation was conducted using the Likert scale as presented; and finally Microsoft Excel and Statistical Package for the Social Sciences v. 24 (SPSS 24) were used to for statistical computations and interpretation of data. The given Likert scale was used to interpret the result of acceptability: 4.51 – 5.00: Highly Acceptable; 3.51 – 4.50: Adequately Acceptable; 2.51 – 3.50: Acceptable; 1.51 – 2.50: Moderately Unacceptable; 1.00 – 1.50: Highly Unacceptable.

RESULTS AND DISCUSSION

Construction Time Frame

It took 33 working days to finish the trainer. This includes the planning until testing as shown in Figure 2. This includes the crafting of the block diagram as presented in Figure 3 until testing.

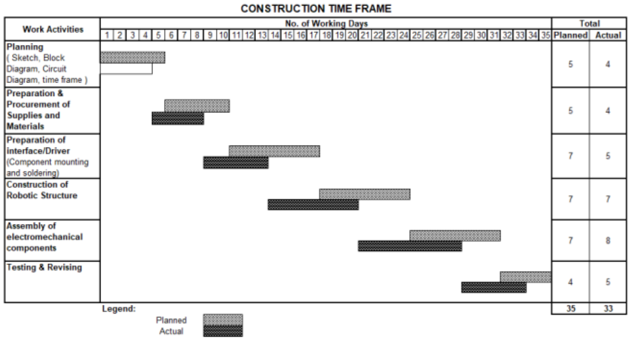


Figure 2. Construction Time Frame

Spent 4 days to finalize the schematic diagrams and sketches for the robotics structures and 9 days to buy the materials needed for the trainer. Seven (7) working days was allotted for the construction of the robotic structures while 13 working days was for the assembly of electromechanical components, testing and revisions.

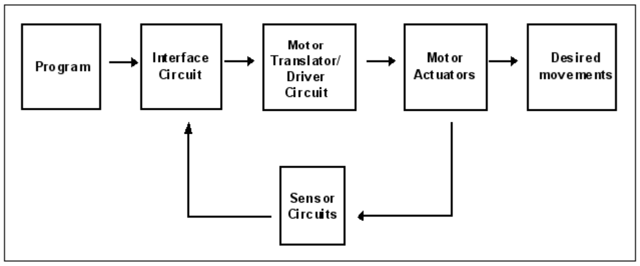


Figure 3. The Block Diagram of the Trainer

Motor translator/ Driver Circuit

A unipolar motor translator/driver kit was assembled and tested. This circuit controlled the movements and step increments of the motor. The motor translator is composed of a preset table up/down binary/decade counter (CD4029BCN), a BCD to decimal decoder CD4028BE and two (2) CD4072BE 4 –Input OR gates that determined the rotational direction both clockwise or counter-clockwise mode, the low output of the microcontroller sets the counter-clockwise mode.

Each stepper motor direction is individually controllable through stepper pulses or frequency by the microcontrollers I/O ports. The four stepper motors were stepped individually. The Translator/driver motor operates in a half stepping motion.

Another very important section of the circuit is the motor driver, which is composed of 4 high current VNP35 MOSFET transistors. The transistors were responsible for the switching of the different coils of the stepper motors. 2 STH54D500, 1.8 degrees step angle, 6.5 VDC and 1.3 Amperes per phase was used for the X and Y axis. The frequency range of the motor is from 50 Hz to 450 Hz. One (1) Astrosyn, 1.8 degrees step angle, 3.9 VDC and 1.3 Amperes per phase stepper motor was used for the Z- axis. This motor is triggered between the frequency ranges from 400 Hz to 1300 Hz.

Interface Circuit

The use of microcontroller was considered to resolve the issue on flexibility. Since microcontrollers were known to be very flexible in varied application, the researcher finally decided to use the Intel Microcontroller 80C652, a microcontroller produced by Philips. This chip is an industry standard with an 8051 core. The microcontroller has 24 I/O ports, built–in RAM where stepper motor directions and stepping pulse were controlled. It allowed the integration of reset and stop sensors for the stepper motors during its initialization and when it reaches the workcell limit of each axes. This is controlled by the microcontroller through its I/O ports. The microcontroller 80C652 pin assignment is shown in Table 2.

Table 2. Microcontroller Pin Assignment

Pin Number	Assignment
Pin 1	Step Pulse of motor 1 (X – Axis)
Pin 2	Direction of motor1 (X - Axis)
Pin 3	Step Pulse of motor 1 (Y – Axis)
Pin 4	Direction of motor1 (Y - Axis)
Pin 5	Step Pulse of motor 3 (Z – Axis)
Pin 6	Direction of motor 3 (Z - Axis)
Pin 7	Extra Port - Additional control of DC Motor
Pin 8	Extra Port
Pin 10	Reset Sensor of Motor 1 (X – Axis)
Pin 11	End Stop of Motor 1 (X – Axis)
Pin 12	Reset Sensor of Motor 2 (Y – Axis)
Pin 13	End Stop of Motor 2 (Y– Axis)
Pin 14	Reset Sensor of Motor 3 (Z – Axis)
Pin 15	End Stop of Motor 3 (Z– Axis)
Pin 16	Extra Port
Pin 17	Extra Port

For the trainer to run, program instructions are needed. These programs are normally stored in a memory chip e.g. erasable programmable read only memory (EPROM).

In this case, various programs are needed to simulate the movements of the different axes. For this case an emulator, a temporary storage, was used to simulate the function of the EPROM.

This was used purposely to facilitate the easy manipulation and fast downloading of the various sets of program instruction desired for the trainer.

Sensor Circuit

The end stop sensor circuit made its contribution by determining the maximum travel length of the different axes. When each of the motors reaches the end of the rail, the opto-coupler/phototransistor changes its resistance then turns on the transistor C9013. The signal from the transistor C9013 gives a 4VDC to the microcontroller sending signal to the motor to stop.

Another sensor circuit is the reset sensor. The reset sensor is very important because during start up, the stepper motors should define the starting position on the railing. By using an opto-couplers and transistors as sensors, a signal is sent to the microcontroller to determine the starting point. This is done during the initialization of the motors when the trainer is turned on.

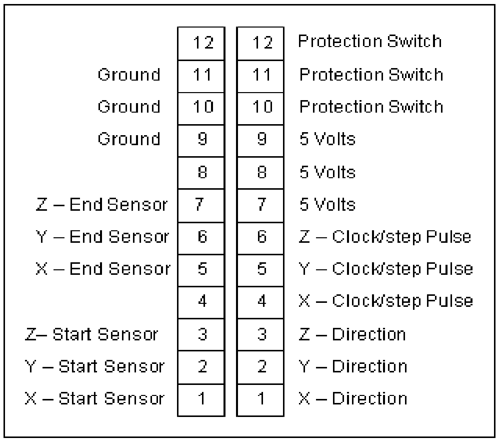
Table 3. Stepper Motor connector

PIN Number	DESCRIPTION
1	Positive supply or ground
2	Positive supply or ground
3	Positive supply or ground
4	A1
5	A1
6	A2
7	B1
8	B1
9	B1
10	A1
11	A2
12	A2
13	B2
14	B2
15	B2

Connector and Terminal Block Pinouts

Various connector pinouts were provided for the interface connection of the educational robotic trainer. This will guide users to avoid improper connections that can damage the trainer or computer interface. For the stepper motors, a DB -15 female connector was used as shown in Table 3.

Terminal Block was also used to facilitate terminations from the interface to the sensors, motor translator/drivers, and protection switches. The terminal block wiring diagram is shown in Figure 4.



	12	12	Protection Switch
Ground	11	11	Protection Switch
Ground	10	10	Protection Switch
Ground	9	9	5 Volts
	8	8	5 Volts
Z – End Sensor	7	7	5 Volts
Y – End Sensor	6	6	Z – Clock/step Pulse
X – End Sensor	5	5	Y – Clock/step Pulse
	4	4	X – Clock/step Pulse
Z– Start Sensor	3	3	Z – Direction
Y – Start Sensor	2	2	Y – Direction
X – Start Sensor	1	1	X – Direction

Figure 4. Terminal Block Wiring Assignment

The Robotic Structure

Originally, the educational robotic trainer structure was a gantry type. As the construction of the trainer progresses, various modifications on the design were introduced alongside with the required adjustments in the system, until a very stable but movable base was fitted.

Reinforced steel was the first choice for the materials of the structure but because it is too labor-intensive and time consuming, the researcher decided to use aluminum alloys.

Aluminum alloy is lightweight, yet sturdy but met the flexibility requirement of the trainer. Its silvery-white color provided aesthetic look and is corrosion resistant. Assembly of structure using aluminum alloy simplified the task.

Testing and Revisions

Upon completion of the trainer testing was done. Several defects were found during the initial testing and they were mostly mechanical in nature. Revisions were done to attain the optimum performance of the trainer.

The researcher was able to address the problem in designing and constructing a prototype of the educational robotic trainer by following the process as presented by Larsen [16], McConell [17] and Cooper and Edgett [18].

Effectiveness of the Trainer in Terms of Students' and Experts' Evaluation

Students' Evaluation

When the trainer was introduced to the students, the researcher observed that the students were more interested in the subject matter. The students were able to understand fully the purpose and operation of the different components when applied to the system.

Based on the data gathered, among the eight criteria, criterion 1 shared the greatest contribution (4.812). Criterion 2 and 6 got the least among the criteria (4.312). An overall average weighted mean (4.492) was obtained having a descriptive rating of adequately contributed. The result provides a clear understanding that the trainer really draws interest to the students towards the course as shown in Figure 5.

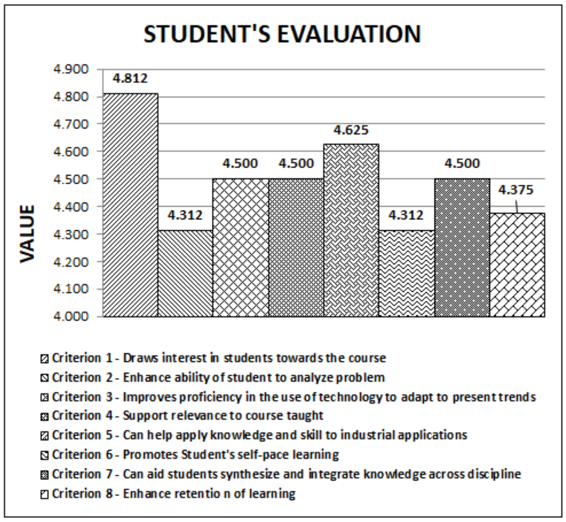


Figure 5. Students' Evaluation

Students as discussed by Cope & Ward [3] and Parr [4] processed their learning based on their interpretation of what they perceived.

Experts' Evaluation

Based on their responses, the researcher was able to assess the effectiveness of the trainer. Most of the experts were satisfied with the performance of the trainer.

On the experts' evaluation, an overall rating (4.812) of "greatly contributed" was attained. Criterion 8 got the highest (4.947) among the eight criteria, while criterion 4 got the lowest (4.684). The graph in Figure 6 presents the experts' evaluation regarding the trainers' effectiveness. Therefore, the trainer really provided intellectual stimulations to the students as supported by

Davies & West [2], Mitchell & Bluer [5], Mollaei, &Riasati [6], Leroux, et. Al [7], Kwietniewski [8], and Anwar &Bascou [9] using other Technology-based Learning.

According to the experts, more trainers must be developed not only for instructional purposes but also for other discrete applications.

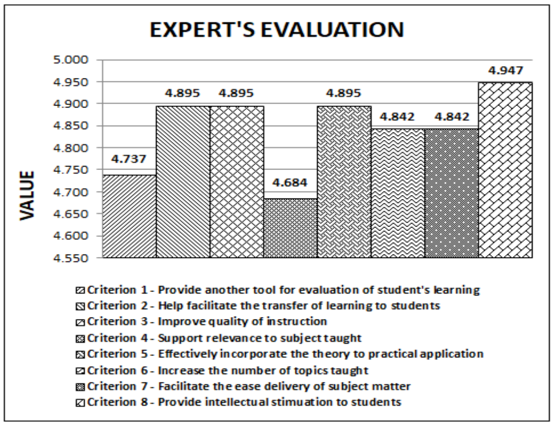


Figure 6. Experts' Evaluation

Effectiveness of the Trainer as to the Students' Learning Outcomes

After the groups were determined, series of lectures and laboratory exercises were done using the conventional method. Both the control and the experimental groups were able to grasp the basic knowledge and skills they need. Then the experimental group was exposed to the trainer; they were able to apply the knowledge derived from previous exercises they performed. Students' enthusiasm in using the trainer was noted by the researcher. The students were capable of integrating the various experiments they perform in a holistic manner. Easy absorption and longer retention of learning were noted due to actual simulation and experience brought about by the trainer. The trainer was the vehicle in imparting to the students the actual situation in the industry.

As noticed, the scores of the post-test of the experimental group have discrete differences as opposed to the control groups. The scores of the pre-test and post-test of the control group reveal the normalness of their assessment.

The control group obtained a mean (15.19) and the experimental group got a mean (22.19). The means explicitly explained the level of achievements the two groups obtained in the post test. These achievements are more exemplified by the standard deviation result showing the homogeneity of the scores of those who used the trainer. The standard deviations were 3.63 and 2.156, for the control and experimental groups, respectively.

A summarized data of T-test computation is present in Table 4. This is shown to give an explanation on how effective the educational robotic trainer in terms of student learning outcomes.

Table 4. Summarized Data of T-Test Computation of the Posttest

Groups	N	Mean	Std. Dev.	Std. Error Mean	T – c	T - t	Sig. Level (2-tailed)
Control	6	5.19	.74	0.936	6.63	.697	.000
Experimental	6	5.37	2.19	0.556			

The t-test result provided a clear explanation that there is a difference between the scores of the post test of the control and experimental groups. Thus, the educational robotic trainer plays a vital role in improving the student learning outcomes.

According to the students, the trainer helped them to be more innovative and creative. They were more enthusiastic in performing their practical and laboratory activities. The trainer has a wide range of applications and very versatile. They recommended the development of software for specific industrial applications.

This affirms according to Mirana [10], Baylon [11], Papert and Harel [12], and Birgili [13] that people generally have higher retention when they themselves have a direct participation in the activity. These activities will eventually develop the students' confidence that will lead to what educators expect of them in the future.

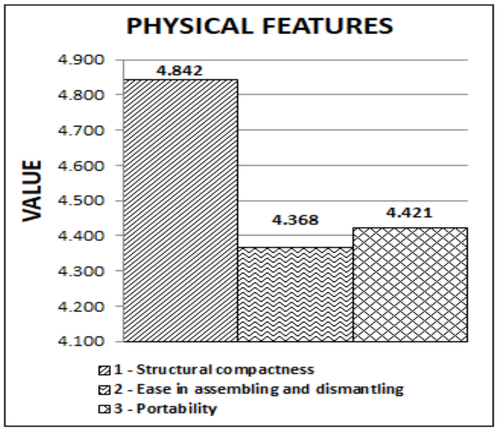


Figure 7. Physical Features

Trainer's Level of Acceptability as Evaluated by Expert

Through the seminar-workshop, the proponent discussed the importance and demonstrated the operation of the trainer. Part of the workshop was letting them try and perform various hands-on activities on the trainer. The experts conducted their evaluation of the acceptability of the trainer using the questionnaire. Several experts suggested various potential applications of the trainer.

Along the Physical Features shown in Figure 7, criterion 1 got the highest score (4.842) while criterion 2 got the lowest (4.368). The trainer got an overall rating (4.544) which is highly acceptable. The evaluation result proved that the trainer was very sturdy due to its structural compactness along its physical features.

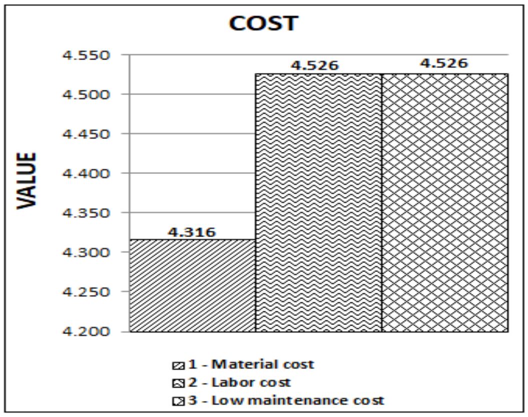


Figure 8. Cost

In terms of cost criterion, the lowest (4.316) was material cost and the highest (4.526) were labor and maintenance cost. A graph on the cost criterion showing the comparison of the different cost criteria is presented in Figure 8. To the expert's opinion the trainer was very costly as to material cost due to the fact that it got the lowest rating which is adequately acceptable only. Yet, the prices of other educational robotic trainers available in the market which offers the same capability is far more costly than this trainer.

As to its durability, the quality and type of materials used have a huge effect in its construction as it lessens the time consumed in the process of making the trainer. From the graph shown in Figure 9, indicated that quality of materials used made a remarkable impact on the experts' evaluation as it got the highest score (4.6840).

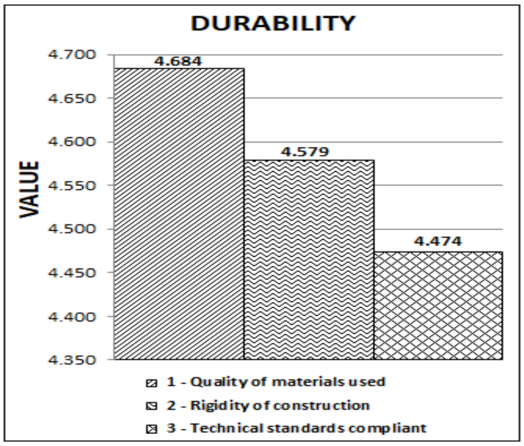


Figure 9. Durability

Even though the researcher gave importance on its compliance to technical standards, the experts' evaluation showed that it is the least of the criterion in terms of durability (4.474) equivalent to an adequately acceptable. The experts gave an overall rating (4.579) equivalent to highly acceptable. The experts 'sound judgement provided a clear manifestation that when developing educational trainers or mock-ups first thing that must be taken into consideration is the quality of material used since students are physically exposed to this trainer.

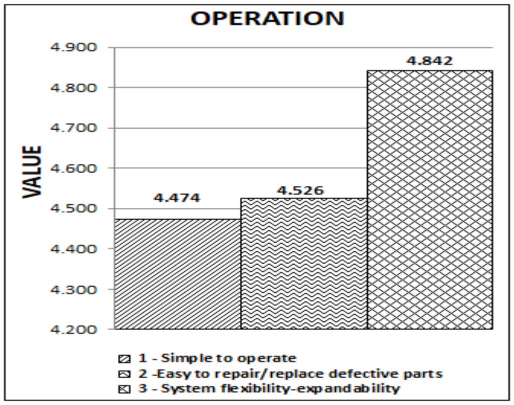


Figure 10. Operation

Along operations criterion, the systems flexibility-expandability criterion has the highest (4.842), while simple to operate criterion got the least (4.474). As presented in Figure 10, the operation criterion got an average weighted mean (4.614) and a rating of highly acceptable.

The simpler the operation of the trainer is the better the students can absorb the knowledge and skills needed. Systems flexibility/expandability is one of the trainers' characteristics allowing students to develop its competencies especially those that are more familiar with other programming languages such as Microsoft Assembly, Turbo Pascal, C++, and visual basic to name a few. The operation criterion affects most of the transfer of learning of the students.

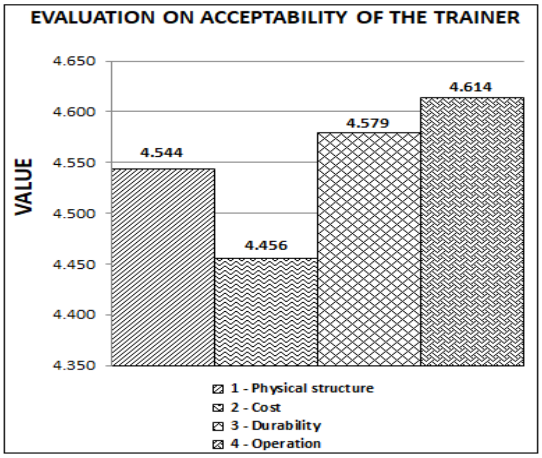


Figure 11. Evaluation on Acceptability of the Trainer

Figure 11 showed the overall average weighted mean (4.548) received by the trainer in terms of the experts' evaluation on the acceptability of the trainer which has a descriptive rating of highly acceptable. From the four general criteria presented, the operation criterion got the highest (4.614) while the cost criterion received the lowest (4.456). The experts' evaluation was focused on the optimum capability of the trainer as an important tool to increase the student learning outcomes.

The results demonstrated a clear manifestation of the relative improvement on the students. If traditional method cannot supplement the needs for the evolving demand, the teacher should take the initiative to devise new strategies in dealing with it.

Educators are given the academic freedom as stated in the Philippine Constitution [1] to choose the most suited and appropriate method to achieve the students' maximum learning potential. This is substantiated by Davies and West [2], Mitchell and Bluer [5], Mollaei, and Riasati [6], Leroux et al. [7], Kwietniewski [8], and Anwar and Bascou [9] on the use of various strategies e.g. laboratory activities, mock-ups and other devices to enhance the learning of the students. This study affirms Mirana [10], Baylon [11], Papert and Harel [12], and Birgili [13]) on its concrete decision that these devices have great effect in the absorption of the students' learning.

Most of the remarks gathered from the experts support the cited literatures in the study.

Accordingly, the trainer serves as a good teaching aid thus facilitate better assimilation of knowledge through practical and laboratory activities and other skills development. The trainer provides a good start for the engineering program for greater advancement in the field. The experts encouraged the researcher to mass produce the trainer not only for teaching but for commercial purposes.

This trainer will not only serve as an instructional medium; but also promote students' creativity to develop marketable products. It also provided more flexibility on the students the freedom to use other programming languages and varied similar applications that would serve as an avenue to implement their learnt skills and knowledge as strengthen by Dewitz and Graves [14], and Davis & Summers [15]. On instruction, research and development, the trainer allowed to take advantage of the principles of learning as cited. As to the educators, it served as an eye opener for them to devise other innovative learning tools.

CONCLUSION AND RECOMMENDATION

A working prototype of the educational robotic trainer was fabricated. This is divided into two major sections namely: the Electronics section and the Mechanical section. The electronics section comprises of: a) stepper motor translator/driver circuit; b) interface circuit; and c) sensor circuit. These three sub-circuits controlled the entire sequencing, sensing, and operation of the trainer. The mechanical section has its four parts: a) the base assembly; b) X-axis assembly; c) Y-axis assembly; and d) Z-axis assembly.

Comprehensive planning and accurate design are needed to develop and construct a prototype of the educational robotic trainer. To attain the desired product's quality: appropriate components, materials' specification and keen observation of the development process and standards must be followed.

The trainer was highly accepted by the experts as an effective learning tool in providing quality student's learning outcomes; similarly, it provides the students opportunities for varied applications, knowledge and skills development during their education. The performance level of students was significantly improved with the lecture – actual hands-on use of the educational robotic trainer [2],[5]-[9].

Lastly, it answers the common problem of learning institutions on the lack of instructional equipment.

It is hereby recommended that integration of mock-ups, learning devices, and trainers in the teaching-learning process of the students to strengthen the retention of knowledge and skills developed during the course of study is necessary. Teachers should be creative and innovative to look for alternatives to ensure a continuous but evolving way of teaching strategy. Actual hands-on, discovery and experimentation methods as approaches in teachings are highly encouraged.

Since, this study has presented information vital to the evolution of teaching strategies, it should pave the way for electronics enthusiasts, teachers, students and engineers to be more creative and to expound their knowledge and skills for further improvement of the present technology.

On the other hand, the learning institution is highly encouraged to support the production of the trainer to address the problem of lack of equipment as suggested in the curriculum and find ways to constantly evaluate curriculum to answer the demands of the outside world.

Further study may be conducted on multi-axes robotics trainer suited for educational and industrial applications.

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