Wind and Sun Energy Turbine Generator: An Educational Technology Instructional Material

Raul R. Bernaldez
Renato M. Castillo
Bulacan State University

ABSTRACT

Financial restraints hamper the provision of specialized teaching equipment that will support both the theoretical and practical aspects of learning power utilization and distribution, which includes the process of generating, distributing, and storing energy. The study was intently considered to design, construct, and evaluate a low-cost teaching tool specifically projected for students of Bachelor in Industrial Technology Major in Electrical Technology of the College of Industrial Technology and other similar courses in Bulacan State University and serve in addition to instant power supply for emergency cases. The researchers used project development research design. Seventy five randomly chosen respondents evaluated the wind-and-sun energy turbine generator in terms of instructional viability, functionality, ease of use, and safety features. The wind-and-sun energy turbine generator was appropriately designed by joining the wind energy turbine generator and solar energy turbine generator with single battery storage and multiple power outlets. The instructional material consists of wind turbine generator and solar panel couple to a single battery storage and utilized a 1000 W inverter to provide 220 V AC to multiple power outlets. It was constructed from efficient, locally available, and recycled materials. The respondents evaluated the IM to be highly acceptable in all criteria. In addition, the construction of wind-and-sun energy turbine generator is easy to operate, simple to maintain, convenient to use and very useful educational simulator.

Keywords*: system integration, project development, construction, functionality*

INTRODUCTION

Economic wise, most of the state universities and colleges in Region III are not financially capable to provide expensive equipment for higher education instruction. The increasing industry demands skilled workers on ASEAN integration and the advent of K to12 curriculum. It posted great challenges on the part of the higher education institutions in improving their collegiate instructions.

The teaching of electrical technology has to be more effective so that the learning process become more meaningful. Appropriate demonstration and satisfactory laboratory activities should be made available. Principles in electricity and exercises in the shop rooms become rationally lasting to students if they are able to confirm and validate through actual experience. Learning is not gained by cerebral activity alone but more in conjunction with tangible practice. This necessitates added resources of practical teaching / training devices.

Incorporating technical and industry-related skills within the instructional materials should be in conformity with the requirements and demands of industry. Universities need to reorient themselves to meet these demands (Narasimharao, 2011). However, Abolade (2009), Olumorin, Yusuf, Ajidagba, and Jekayinfa (2009) emphasized that it is when original materials are not available for use in teaching and learning, that other types and forms of instructional can be applied. Also, reported that most of the factory produced instructional materials for teaching art-based courses are usually very scarce to come by and where they are within reach, they are usually very expensive to buy (Abolade and Oumorin, 2004). Some of the factory produced/imported instructional materials have also been discovered to be concept-based on foreign ideas and culture (Olumorin, 2009).

The shortfall of teaching devices is a common problem in most state universities and colleges including Bulacan State University due to national budget-cut. Resorting to the idea of fabricating devices using locally available supplies and materials is one of the considerations. Improvisation of device is a practical response to the call of time for cost-cutting measures. The economic dilemma imposes a dire need for resourcefulness and creativity.

Ecological wise, growing population means growing energy consumptions. Fossil fuels have been used to power most of society's residences and commercial establishments but are obviously running down at a fast rate. Crude oil market costs have escalated swiftly in a matter of time. One day, the world might run out of natural energy source from earth. The early recourse to be pulled up is to revisit the primitive and infinite energy source.

The impact of wind and solar energy on people's life is immense and valuable. The light and wind energy from the sun and air are the most abundant and readily available sources of energy (Venture Solar, 2017). Diverse innovations and ever-evolving technologies were drawn from wind and solar energy by human kind. The earth receives more energy in just an hour from the air and sun than what is consumed in the whole world for a year (Venture Solar, 2017). There is a vast potential from air and sun energy.

An and Singh (2011) in their study in Malaysia on Solar Wind Hybrid Power Plant unveiled results on data indicating factors, such as solar positioning, solar irradiance, photovoltaic array (PV) operating temperatures and efficiency and operating locations that influence solar power output of PV arrays and comprehensive sizing data for regional implementation, while at the same time, addressing issues relating to reliability and sustainability of existing standalone solar power plants.

Ketterer (2012) in his investigation mentioned the relationship between intermittent wind power generation and electric price in Germany. He used statistical GARCH model in studying the effect of wind electricity in-feed on level and volatility of the electricity price that was assessed in an integrated approach. His results showed that varied wind power decreases the level of price but increases its volatility. With a low and volatile wholesale price, the profitability of electricity plants, renewable /conventional, is more unstable. Additionally, the construction of new plants is at risk, which has better implications for the energy and security market of supply. These problems, related to the integration of renewables, require adjustments to the regulatory and the policy framework of the electricity market. These results suggest that regulatory change is able to stabilize the wholesale price. It is found out that the electricity price volatility has decreased in Germany after the marketing mechanism of renewable electricity was modified.

Jones and Bouamane (2012) in their study on power from sunshine which is a business history of Solar Energy explored the role of entrepreneurial actors, motivated by broad social and environmental agendas, whose strategies to build viable business models proved crucially dependent on two exogenous factors: the prices of alternative conventional fuels and public policy. Supportive public policies in various geographies facilitated the commercialization of photovoltaic technologies, but they also encouraged rent-seeking and inefficiencies, while policy shifts resulted in a regular boom and bust cycle. The perceived long-term potential of solar energy, combined with the capital intensity and cyclical nature of the industry, led to large electronics, oil and engineering companies buying entrepreneurial firms in successive generations. These firms became important drivers of innovation and scale, but they also found solar to be an industry in which achieving a viable business model proved a chimera, while waves of creative destruction became the norm.

Ingole and Rakhonde (2015) in their study on hybrid power generation system using Solar and Wind Energy mentioned that all the conventional energy resources are depleting daily they shifted from conventional to non-conventional energy resources. In this the blending of two energy resources took place, wind and solar energy. This method reviled the sustainable energy resources without destroying nature. They gave uninterrupted power by using system of hybrid energy. This involved the integration of two energy methods that provided continuous power. Solar panels were used for converting solar energy and wind turbines were used for converting wind energy into electricity. This electrical power was used for various purposes. Generation of electricity took place at affordable cost.

This present study focused on energy from air, sun and storing the power supply until the needs arise to use it up, both in principles and in practice. Financial incapability and environmental exploitation are the primary concerns of conducting this study. Educators keep up on finding ways to work out these needs and problems.

This study is particularly beneficial to educators and students from the fields of Electrical Technology teaching and learning subject course on power utilization and distribution. The teaching tool is simply designed to provide practical learning experience for students. Work values may be developed in utilizing this teaching tool, such as, patience, creativity, resourcefulness, logical reasoning, environmental awareness and concern, and civic consciousness.

This study aimed on designing, constructing, and evaluating a low-cost and environment-friendly teaching tool specifically intended for Bachelor in Industrial Technology students specializing in Electrical Technology of the College of Industrial Technology. The study intends to: (1) determine a proper design that will integrate wind and solar energy lessons in a teaching tool, (2) construct wind-and-sun energy turbine generator suitable for teacher's instructions and students' learning experiences, and (3) evaluate the level of acceptability of the wind-and-sun energy turbine generator based on the following criteria: (a) instructional viability, (b) functionality, (c) ease of use, and (d) safety features.

The Wind-and-Sun Energy Turbine Generator was guided by the input-process-output model in Figure1.

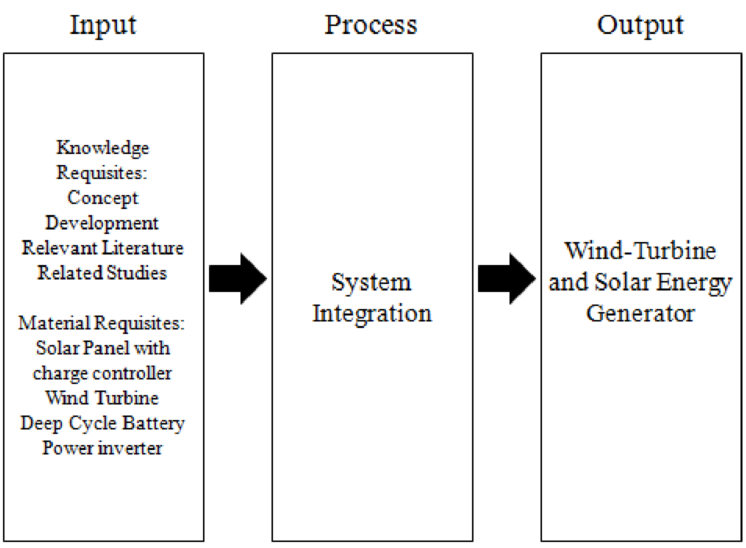

Figure 1. Conceptual Model of the Study

The input frame shows the: (1) knowledge requisites that include concept development, relevant literature, and related studies; and (2) material requisites that involve solar panel with solar controller, wind turbine, deep cycle battery and power inverter.

The process frame involves the designing, constructing, and evaluating of the wind-and-sun energy turbine generator.

The output frame comprises the wind-and-sun energy turbine generator.

METHODOLOGY

The researchers made use of the project development research design. The project was conceptualized for the researchers to come out with an instructional tool to be used by the faculty and students of the Bulacan State University, Philippines. The researchers began by looking into a number of literatures and reading materials related to the study. The researchers drafted a schematic design for wind-and-sun energy turbine generator.

Design of Wind-and-Sun Energy Turbine Generator

Figure 1 presents the schematic diagram of wind-and-sun energy turbine generator that served as guide prior to its construction.

The aforementioned diagram was followed by the researchers religiously in the construction of the Teaching tool.

Materials and Costs in the Construction of Wind-and-Sun Energy Turbine Generator

Table 1 presents the inclusive cost of the construction materials used for assembling wind-and-sun energy turbine generator. The construction material cost reflects the quantity, item description, and price. The items used for the construction were combination of second-hand and brand new articles. There were also items categorized as consumable supplies because they were completely expended during the construction process. Most of the materials were bought in Cubao (Metro Manila), Bulacan, and Pampanga.

Table 1
Construction Material Cost

Quantity	Item Descriptions	Price
1 piece	wind turbine	PhP 25,000.00
1 piece	solar panel with solar controller	PhP8,000.00
1 piece	deep cycle battery	PhP 5,700.00
1 piece	power inverter	PhP 1,200.00
7.5 meters	aluminum angle bar (2x2)	PhP 240.00
2 sets	CP30-BA 10A (CKT. Breaker)	PhP 700.00
1 piece	CP30-BA 3A (CKT. Breaker)	PhP 300.00
1 piece	ABB CKT. Breaker 16A	PhP 450.00
1 roll	auto wire #16	PhP 240.00
6 meters	stranded wire #12 (THHN)	PhP 228.00
3 pieces	acrylic glass 3/16 28cm x 19cm	PhP 2,200.00
2 pieces	shelf-bracket	PhP 20.00
1 piece	DC Voltmeter	PhP 230.00
1 piece	DC Ammeter	PhP 200.00
1 piece	AC Voltmeter	PhP 230.00
1 piece	AC Ammeter	PhP 320.00
2 pieces	toggle switch	PhP 80.00
2 meters	stranded wire #8	PhP 90.00
4 pieces	rubber tip	PhP 60.00
7 kilo	Angle bar	PhP 210.00
12 kilo	Metal sheets	PhP 900.00
4 pieces	wheels	PhP 104.00
8 pieces	Allen screw	PhP 160.00
1 feet	spaghetti tube	PhP 25.00
1 piece	indicator light	PhP 20.00
12 slots	terminal block	PhP 140.00
2 pieces	study lamp	PhP 200.00
1 piece	spray paint (top coat)	PhP 100.00
1 piece	spray paint (fluorescent orange)	PhP 150.00
2 pieces	spray paint (flat black)	PhP 240.00
1 piece	DC bulb (5watts)	PhP 150.00
1 piece	AC bulb (5watts)	PhP 90.00
1 piece	sticker paper	PhP 12.00
1 set	battery terminal	PhP 170.00
4 pieces	fabrication of adjustable stand	PhP 720.00
1 piece	fabrication of panel holder	PhP 520.00
1 piece	exhaust fan	PhP 70.00
1 piece	exhaust fan cover	PhP 15.00
150 pieces	cable tie	PhP 45.00
2 pieces	door handle	PhP 70.00
1 piece	cabinet handle	PhP 25.00
1 piece	battery holder	PhP 150.00
1 piece	car lighter w/ outlet	PhP 150.00

Quantity	Item Descriptions	Price
18 sets	bolt and nut w/ flat washer (25mm size 10)	PhP 432.00
18 sets	bolt and nut w/ flat washer (18mm size 8)	PhP 360.00
8 sets	bolt and nut w/ flat washer (25mm size 8)	PhP 176.00
4 sets	bolt and nut (18mm size 14)	PhP 100.00
1 piece	hacksaw blade	PhP 69.75
3 pieces	sandpaper (2x120, 1x400)	PhP 45.00
½ kilogram	welding rod	PhP 60.00

Construction materials like CP30-BA 10A (CKT. Breaker), CP30-BA 3A (CKT. Breaker), ABB (CKT. Breaker 16A), DC Voltmeter, DC Ammeter, AC Voltmeter, AC Ammeter, toggle switch, terminal block, and exhaust fan were bought second-hand by the suppliers or colleagues who do not need anymore. The rest of the construction materials were bought brand new, like wind turbine, solar panel with solar controller, deep cycle battery, aluminum angle bar, auto wire #16, stranded wire #12 (THHN), acrylic glass, shelf-bracket, stranded wire #8, rubber tip, angle bar, metal sheet, wheels, Allen screw, spaghetti tube, indicator light, study lamp, DC bulb, AC bulb, sticker paper, battery terminal, adjustable stand, panel holder, exhaust fan cover, cable tie, door handle, cabinet handle, battery holder, car lighter with outlet, and bolts and nuts with flat washers. Consumable supplies that aid in the finishing phase of the wind-and-sun energy turbine generator were spray paints, hacksaw blade, sandpaper, and welding rod.

Table 2 presents the construction cost of the wind-and-sun energy turbine generator. The total cost of construction materials amounted to PhP 51,166.75, which were bought, processed, and fitted together. The development cost is the expenses acquired in the replacements, repairs, and adjustments made on minor parts of the wind-and-sun energy turbine generator during testing that amounted to PhP 5,321.50. The total construction cost recorded an amount of PhP 56,487.75.

Table 2
Construction Cost

Particulars	Amount
Construction Materials	PhP51,166.75
Development Cost	PhP5,321.50
Total	PhP56,487.75

Construction Procedure

The solar panel of 70 watts and 12 volts output, independently set up straight and supported with foldable tripod stand, was connected with 16 Ampere circuit breaker, which was directly mounted onto the WSTG (wind-and-sun turbine `generator) box. DC (direct current) voltmeter and DC Ammeter were fixed together side by side. The 12VDC (volt direct current) indicator light was mounted and connected in parallel position with DC Ammeter. The solar charger controller was mounted onto the WSTG box and connected to 12VDC outlet and 12VDC lamp with a series of toggle switch. The circuit breaker was mounted onto the WSTG box and connected in parallel to the 12VDC deep cycle battery. The wind turbine, independently set up straight and supported with foldable tripod stand, was connected to 12VDC deep cycle battery with cut out circuit breaker. The 12VDC deep cycle battery mounted on the WSTG box was connected to 1000 watts power inverter installed with 35 Ampere fuse. The 3- Ampere circuit breaker mounted onto the WSTG box connected with AC (alternating current) Ammeter and AC Voltmeter. The 220VAC (volt alternating current) convenience outlet was mounted onto the WSTG box connected to 220VAC lamp with one toggle switch that controls the AC lamp.

The methods employed in the construction of the project were: measuring, cutting, drilling, assembling. The wind-and-sun energy turbine generator took twenty-five (25) working days for it to get done. The equipment was tested several times at the roof top of Alvarado Hall, which is a three-storey building. Necessary adjustments were made.

The wind-and-sun energy turbine generator was observed and evaluated by randomly chosen 25 faculty and 50 Bachelor in Industrial Technology students specializing in Electrical Technology, hence a total of 75 respondents. A follow –up interview was done to all of them on the performance of the instructional material and safe usage.

The research instrument used for evaluation was self-made and validated by five experts of the field. The statistical treatments used in this study were frequency and weighted mean. Data were gathered, tallied, tabulated and interpreted.

The norms in interpreting the level of acceptability of the constructed Wind and-Sun Energy Turbine Generator are as follows:

Mean Range	**Item Descriptive Rating**	**Overall Descriptive Rating**
4.25 – 5.00	Highly Acceptable	Excellent
3.45 – 4.24	Moderately Acceptable	Very Good
2.65 – 3.44	Acceptable	Good
1.85 – 2.64	Slightly Acceptable	Fair
1.00 – 1.84	Not Acceptable	Poor

RESULTS AND DISCUSSION

Constructed Instructional Material

Figure 2 shows that the wind turbine is separately set up straight with a tripod supporting it for stability. The solar panel is also separately set up straight with a tripod but the panel is tilted by an adjustment knob. The wind-and-sun energy turbine generator (WSETG) box is situated in between the wind turbine and solar panel. The WSETG box holds the solar controller, power inverter, AC/DC volt meters, AC/DC volt Ammeters, 220 volts lamp, 12 volts lamp, circuit breakers, fuse, indicating lamp, 12 volts deep cycle battery, electric wires, automotive wires, cable ties, toggle switches, 12 volts DC outlet, and terminal blocks.

Figure 2. Wind-and-Sun Energy Turbine Generator Schematic Diagram

Evaluation of Wind-and-Sun Energy Turbine Generator

As shown in Table 3, the level of acceptability of the wind-and-sun energy turbine generator by the respondents in terms of instructional viability, functionality, ease of use, and safety features registered as **highly acceptable** with mean ratings of 4.87 as the highest and 4.59 as the lowest respectively.

Table 3
Level of Acceptability of Wind-and-Sun Energy Turbine Generator

Evaluation Criteria	Mean	Remarks
1. Instructional viability	4.87	Highly Acceptable
2. Functionality	4.73	Highly Acceptable
3. Ease of use	4.66	Highly Acceptable
4. Safety features	4.59	Highly Acceptable
Grand Mean	**4.71**	**Excellent**

The respondents evaluated the wind-and-sun energy turbine generator a Grand Mean of 4.71 described as ***Excellent*.** It implies that they perceived that the constructed new generator worked successfully as an instructional material ,functioned well, easy to use and is very safe and no encountered problems . The use of it deepened and broadened the perceived students' understanding in the theory and practice of power generation. Furthermore, the teaching tool aided students in generating greater insights and self-awareness. The wind-and-sun energy turbine generator provided a tool for students to assess and develop their own skills on power utilization and distribution. It facilitated application of power utilization distribution, knowledge and skill learned in the classroom.

Ifeoma (2013) stated that the use of instructional materials provide an enriched classroom atmosphere. The instructional viability of the project explains the feasibility of the equipment in the teaching of Power Utilization and Distribution to students in Bachelor of Industrial Technology (BIT) major in Electrical Technology. The Power Utilization Distribution subject involves complex theories and principles but must couple with practical applications. The skills are needed to be harnessed because the students in BIT major in Electrical Technology are involved in actual installation in the electric industry. In connection with this, the provision of the said tangible educational technology tool such as the Wind-and-Sun Energy Turbine Generator just constructed, the principles and theories are being simulated in classroom settings. The students were given opportunity to have firsthand experience of manipulating the physical components of the Wind-and-Sun Energy Turbine Generator. Student learning is enriched through the use of this educational tool.

Summary of respondents' descriptions on the Performance and Safety of the Wind-and-Sun Energy Turbine Generator

The function of the Wind-and-Sun Energy Turbine Generator is mainly inverting the clean energy into electric energy. The major features of the Wind-and-Sun Energy Turbine Generator are: (1) charging station for five volt devices like cellphones; (2) lighting up 220 volts and 12 volts electric lamps; (3) powering up of machines like, household electric fan, personal laptop, and television set; and (4) heating up of cigarette outlet/plug.

With these functions and features, the respondents when interviewed described the wind-and-sun energy turbine generator as an ***excellent tool*** which is practical, useful, working, operating, and can deliver quality service to users well.

The respondents further professed that the wind-and-sun energy turbine generator constructed is easy to learn. For entirely inexperienced students who are after a short, informal training period were able to use the teaching tool. The function of educational tool is important in the teaching and learning process.

They further claimed that the ease of use of the Wind-and-Sun Energy Turbine Generator provides comfort and convenience in its use. It is designed within the reach of individuals with various heights. Its physical components can be disassembled and can be rewired. It can be lifted up by two (2) students at the same time. There is a provision of proper labels of the parts.

The respondents mentioned too that the wind-and-sun energy turbine generator is easy to manage. They were able to operate quickly the wind-and-sun energy turbine generator without being burdened by pressing and switching on the buttons because these are properly labeled and sequentially installed. The teaching tool displayed ease of use once learned. The students enjoyed using it as shown in the users' positive attitude. They mentioned it was effective and working so well.

The safety features of the Wind-and-Sun Energy Turbine Generator include the use of industrial circuit breaker and fuse. The wind turbine and solar panel are commonly situated outside the elevated building for wind and sun exposure where authorized people only have been given access to it. When it will be used for class discussions, the units are easy to carry from outside of the building going inside the classroom.

Lastly, the respondents mentioned that there is nothing to fear of using the wind-and-sun energy turbine generator. There is a very low probability of breaking the parts, or harming self while using it. The teaching tool induces a very inferior anxiety factor.

CONCLUSIONS

Based on the findings of the study, the wind-and-sun energy turbine generator was appropriately designed by joining the wind energy turbine generator and solar energy generator with single battery storage and multiple power outlets. The wind-and-sun energy turbine generator could be constructed by using inexpensive but efficient, locally available and recycled materials. It was evaluated to be excellent tool in teaching. In addition, the wind-and-sun energy turbine generator is easy to operate, simple to maintain, and convenient to use. It is a very good simulator useful for instruction and serves well as instant power supply for emergency cases.

RECOMMENDATIONS

Based on the conclusions of the study, the following recommendations were drawn: Wind-and-sun energy turbine generator should be used by the Bachelor in Industrial Technology Major in Electrical Technology as a teaching tool in their classes; should be situated in windy areas like those near the seashores and high places where wind speed is high and sunlight is abundant. It should be provided with special covering or protection against external forces that may directly impair it; and wind-and-sun energy turbine generator should be provided with notices or precaution labels to remind users to constantly check the specification and type of appliances for power outages compatibility.

LITERATURE CITED

Abolade, M.A. (2009). Effects of lack on instructional materials. Retrieved on January 3, 2016 from http://www.academia.edu/13158439/effects_of_lack_on_instructional_materials

Abolade, A.O. and Olumorin, C.O. (2004). Learning and instructional media in tertiary institutions. Retrieved on January 2017 from https://www.musero.org.ng/publications/DEVELOPMENT-OF-INSTRUCTIONAL-MATERIALS-FROM-LOCAL-RESOURCES-FOR-ART-BASED-COURSES.pdf

Ifeoma, M.M. (2013). Use of instructional materials and educational performance of students in integrated science (a case study of Unity Schools in Jalingo, Taraba state, Nigeria). Retrieved on January 2017 from http://iosrjournals.org/iosr-jrme/papers/Vol-3%20Issue-4/B0340711.pdf?id=7221

Ingole, A. and Rakhonde, B. (2015). Hybrid power generation system using wild energy and solar energy. Retrieved on August 20, 2016 from www.ijsrp.org/research-paper-0315/ijsrp-p39109.pdf

Ketterer, J. (2012).The impact of wind power generation on the electricity price in Germany. Retrieved on August 4, 2016 from https://www.cesifo-group.de/DocDL/IfoWorkingPaper-143.pdf

Olumorin, C.O., Yusuf, A., Ajidagba, U.A., and Jekayinfa, A.A. (2009). Development of instructional materials from local resources for art-based courses. Asian Journal of Information Technology, 9 (2), pp. 107-110. Retrieved on June 6, 2016 from http://www.medwelljournals.com/fulltext/?doi=ajit.2010.107.110

Olumurin, C.O., Yusuf, A., and Ajidagba, U.A. (2004). Development instructional materials from local resources art based courses. Retrieved on January 6, 2017 from https://www.scribd.com/document/68619369/Development-Instructional-Materials-From-Local-Resources-Art-Based-Courses

MassHighway (2006). Project development. Retrieved on January 5, 2017 from http://www.massdot.state.ma.us/Portals/8/docs/designGuide/CH_2_a.pdf

Jones, G. and Bouamane, L. (2012). Power from sunshine: A business history of solar energy. Retrieved on August 3, 2016 from www.hbs.edu/faculty/Publication%20Files/12-105.pdf

Venture Solar (2017). The importance of solar energy. Retrieved on June 2, 2017 from https://venturesolar.com/blog/the-importance-of-solar-energy/

ACKNOWLEDGEMENT

The researchers would like to extend their sincerest gratitude to Bulacan State University for allowing the researchers to conduct this study, likewise to the validators and respondents of the study.