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TECHNOLOGY-BASED CURRICULUM DEVELOPMENT TOWARDS PHILIPPINE QUALIFICATION FRAMEWORK

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Abstract: This paper presents the University of Science and Technology of Southern Philippines initiative towards the adherence to the Philippine Qualification Framework (PQF). The study articulated the struggle for academic and professional identity of industrial technology program in the absence of Policies, Standards and Guidelines from the Commission on Higher Education. Such predicament is also confronted with the gap between the levels of educational qualifications described in the PQF wherein the transition in the vocational education to the baccalaureate degrees is scrutinized. The objective of the initiative is to develop a technology-based programs in conjunction with the Outcomes-based Education and the PQF. The university followed the concept of Develop a Curriculum in the program development taking into consideration the inputs from the industry and other stakeholders at the same time emphasizing the differentiating characteristics of Sydney and Dublin Accords in the crafting of program outcomes in the course syllabus. A technology program continuum was also develop describing the transitional year level of technology programs offered in the university wherein the first three years are classified as Diploma program with yearly exit options. At the end of the three-year technician-based engagement the students may opt to proceed to the corresponding baccalaureate degrees in technology, teacher education and engineering or exit for employment. The outcome of the study resulted to the offering of five (5) technology programs that started in School Year 2018-2019 duly approved by the Board of Regents of the university.

Index Terms **- continuum, qualification framework, outcomes-based, technician-based, technology-based**

I. Introduction

Since time immemorial the industrial technology program offered by most State Universities and Colleges (SUCs) in the Philippines struggled to find its academic and professional identities. It has been observed that in some aspect of budget allocation and other priorities of their institutions, technology-based programs are at the least. This may be validated by the report of Bacani (2014) [1] from an article published by the Philippine Star that excluded the industrial technology program from the list of in-demand priority college courses in the Philippines. The list was corroborated by the list of in-demand college courses published by CHED that excluded industrial technology [2]. However, Suarez (2013) [3] mentioned in the Rappler article “Unpopular Course: the Road Less Travelled” which quoted CHED designating priority disciplines or field of study that will be focused for growth and are seen as vital in the country’s development in which engineering and technology courses are among the qualified. The opposing scenario may be ascribed to advocacy deficiencies where industrial technology programs were not appropriately promoted and disseminated to the secondary schools and the community. Program advocacy is important to promote innovative programs featuring their academic and economic impacts to various sectors as such the viability of courses are determined.

Another shortcoming are anchored on the occupational treatment of graduates in the industry where the preference for job placement favors the graduates in engineering. There are varied reasons of these predicaments that might be attributed to the quality of input, institutional academic and physical facility inadequacies, access to national certification and professional licensing. Most often, the industry is so concern on skills mismatch where there are imbalances between formal qualification and required occupational qualifications as well as discrepancies between skill demand and supply [4]. Any disparities between the abilities of available workers and the requirements for open positions can be considered structural unemployment [5]. The future of industrial technology programs in the Philippines is at stake if the occurrence of job-skills mismatch continue to persist which means that academic programs fail to institute quality and relevant programs. In essence, the current technological innovations and dynamic of change in work organizations and economies will continue to fuel compelling debates on the future of the labor market and the exigency of skills upgrading requirements [5]. These are compelling challenges that continue to confront SUCs in the Philippines that place the industrial technology programs in danger of extinction.

The unpopularity of industrial technology programs may also be ascribed to the absence of policies, standards and guidelines (PSG) promulgated by the Commission on Higher Education (CHED) thus, enrolment preferences to technology-based programs are undersubscribed. Likewise, funding priorities to these programs are less dedicated and therefore inadequately feasible academically. Moreover, apart from the traditional program content populated with irrelevant outdated courses, inadequate skill set among faculty members due to institutional failure to introduce modern enabling tools and techniques. The insufficient supply and poor quality of these educational basics create significant obstacles for students as they attempt to meet the industry standards that are required to qualify for competitive opportunities in the workplace [6].

Currently, the industrial technology program strives to secure the affirmation of the CHED through the initiative of the Philippine Association of Colleges and Universities of Industrial Technology (PACUIT). PACUIT has been working overtime to craft a proposal leading to the provision of the PSG for Industrial Technology by convening its corresponding national experts in the industry and the academe in the discussion of relevant provisions for submission to the competent authorities. This long overdue PSG for Industrial Technology may finally be realized in the light of the CHED Memorandum Order (CMO) requiring all programs to secure Certificate of Program Compliance (COPC) to continuously avail the privileges under the Unified Financial Assistance System for Tertiary Education Act, or UniFAST, also known as Republic Act No. 10687. De Vera (2018) [7] emphasized in the CHED's memorandum that failure to secure COPC would mean exclusion from the UniFAST. It is perceived that through this regulations the academic institutions might be able raise the bar of excellence in education that is worthy of international recognition via its corresponding accords for engineering, technology, and technician. Hence, the outcomes-based education has been mandated for all higher education that might be the key to internationalization of academic programs in the Philippines.

Another initiative of similar direction is the promulgation of the Philippine Qualification Framework (PQF) which is a quality assured national system for the development, recognition and award of qualifications based on standards of knowledge, skills and values acquired in different ways and methods by learners and workers educated/trained in the Philippines [8]. One of the objectives is to support the development and maintenance of pathways and equivalencies which provide access to qualifications and assist people to move easily and readily between the different Engineering & Technology sectors and between these sectors and the labor market. It intends to align the PQF with international qualifications framework to support the national and international mobility of workers thru increased recognition of the value and comparability of Philippine qualifications. PQF encourages lifelong learning to allow individuals to start at the level that suits them and then build-up their qualifications as their needs and interests develop and change over time. It provides access to certificates and licenses recognized by government. PQF is an initiative towards the internationalization of the country's educational qualification system in conjunction with the ASEAN Qualification Reference Framework (AQRF) which is a common reference framework that enables comparisons of education qualifications across participating ASEAN Member States (AMS) [9]. Hence, programs that adhere to the PQF will be recognized in accordance to AQRF. PQF is expected to change the mindset of the public towards technical education.

However, there are challenges posed by the PQF looking at the transition between the levels of educational qualifications between Level 4 and Level 6 particularly Level 5 that intends to be considered as the diploma level. While Level 4 is obviously under the turf of the Technical Education and Skills Development Authority (TESDA) and Level 6 is under the responsibility of CHED, a transition gap at Level 5 might cause learning discontinuity to the educational qualification. Since Level 5 is the area that has to be addressed in terms of strategic approach to filling the transitional gap. It is perceived that the industrial technology programs in the Philippines might play a very significant role in arresting this problem through careful curriculum design and development that addresses the knowledge, skills and values that connects Level 4 and Level 6. Hence, the motivation of this study is anchored on the design and development of technology-based programs that are in conjunction with the outcome-based education (OBE) and PQF which can be translated into qualification equivalency of other ASEAN counterpart and to international accords. International accords mandate that academic programs should have unique differentiating characteristics in consonance to Sydney and Dublin accords and that their graduate attributes must be distinct [10].

The general objectives of this study are to determine the current trends of the industry, the enabling tools and its corresponding skill set requirements at the same time determine the corresponding duties, tasks, tools and equipment inherent to the programs using the DACUM research chart. The outcome of this study is the crafting of technology-based programs detailed with corresponding courses.

II. METHODOLOGY

There are two major research endeavors in this study, the "analysis of industrial automation enabling tools and occupational skill set requirements" and "curriculum review and development of a hybrid industrial technology program".

2.1 Analysis of industrial automation enabling tools and occupational skill requirements

The study addressed the issue on job-skills mismatch in the industry most specifically in the areas where industrial technology graduates are most likely fitted to work. As more products and processes have included mechatronics system, it has become necessary for employees designing and working in technologically advanced environment to be competent in the multi-disciplinary application of its various technologies [11]. Hence, corresponding technology-based programs should be anchored on these demands assessing the current enabling technology utilized by the industry and the academe. Likewise, an evaluation of current occupational skill set demands in the industry and the academic program skill set. The assessment process utilized purposive sampling across highly automated industries and academic institutions of higher learning offering technology-based programs in Northern Mindanao. Descriptive statistics was utilized in the analysis of data gathered from various industries, academic institution offering technology-based programs and students. [12]. The survey was administered using the five –point rating scale with corresponding adjectival ratings.

A survey instrument was designed to certify the use of mechatronics enabling tools in the industrial control platforms and the entry-level skills competency requirements perceived by the industry as necessary for technologist and technicians for a successful occupational placement. There were 30 questionnaires used in each of the pre-selected industries classified and coded as manufacturing (M), food & beverages (FB), chemical (C), power (P), and cement & metals (CM). Academic institution (A) and students (S) were also assessed.

2.2 Curriculum review and development of a hybrid technology-based program

This portion of the study validated the inputs from various industry and other stakeholders during a well-planned industry-academe forum. The purpose of which was to solicit the relevant occupational needs and entry-level competencies from competent speakers and consultants. The endeavor follows the DACUM process of crafting creative and innovative technology-based programs in the university. It was perceived that based on the duties and tasks identified by the industries as necessary in their workplaces, the corresponding skills and competencies constitute the needed courses/subjects and enabling tools per curricular discipline. Likewise, crafting of course syllabus following the OBE frameworks were followed taking into consideration the “Sydney and Dublin accords” and the PQF.

III. . RESULTS AND DISCUSSION

3.1 Analysis of industrial automation enabling tools and occupational skill requirements

There were ten (10) industries and three (3) academic institution who participated on the assessment process each was allotted for 30 questionnaires that yielded return rates classified as: (a) 33.33% manufacturing (M), (b) 86.67% for food & beverage, (c) 50% for chemicals, (d) 50% for power, (e) 83.33% for cement & metals, (e) 50% from the academe. Each survey respondents exercised their sound judgment based on their respective experiences and actual industrial practices.

The assessment process validated the previous declaration that the industrial trends are now shifting to integration of multiple technologies especially in the industrial automation platforms. Philippine industries confirms and recognizes that mechatronics is an enabling component of many emerging products, processes, industries and cutting-edge technologies that is increasingly applied in varied economic sectors [13]. Mechatronics is at the heart of industry application diversity for much-improved quality and productivity [11]. These notions are validated in the assessment.

Table 1 shows that most survey participants gave very high marks to mechatronics applied technologies except for Distributed Control system (DCS), Supervisory Control and Data Acquisition (SCADA), which are more popular in the power industry. DCS and SCADA applications are best utilized in highly advanced industries wherein microcontroller-based industrial machines demand flexible control and management of redundant systems. However, DCS, SCADA, robotics and internet of things (IOT) yielded fair treatment from the industry which means that theses enabling technologies have not been embraced thoroughly or have not yet been adopted for application. Likewise, the academic survey resulted in a varying fair to poor mean responses which means that among the enabling tools in the industry, the academe have yet to possess them physically or might be considered inadequately utilized in the academic settings. As per the result of a focus group discussion (FGD), most academic institution are confined on mere theoretical aspect of instruction delivery owing to the cost involved in the acquisition of state-of-the-art equipment. However, the academe are now starting to engage in robotics for at least in the entertainment and educational level. The high mean responses were indicative of program innovations present in the academe because of the cost of microcontrollers and its accessories are less costly. The availability of various microcontrollers and its accessories are now readily available in the local market as such its accessibility to any creative projects are now possible. There were disparity among the industry’s utility of mechatronics enabling technologies which are attributed to their differing range of utility depending upon their kind of processes and platforms. Likewise, a big disparity between the enabling tools used by the industry and the academic utility are obviously ascribed to cost, skill set and inadequate institutional will to cope up with the trends of the economy. The survey participants from the academe were program chairperson and relevant senior faculty of technology-based programs.

Table 1. The composite Mean Responses of applied mechatronics range in the industry and academe

Enabling Technologies in Mechatronics	Mean Value Industry Classification* M	FB	C	P	CM	# A
Electro-pneumatics	4.4	4.8	4.6	4.5	4.4	3.2
Electro-hydraulics	4.7	4.6	4.6	4.8	4.8	2.8
Programmable Logic Control	4.9	4.7	4.8	4.7	4.8	2.8
Instrumentation & Process Control	4.7	4.6	4.8	4.8	4.7	2.2
Motor Controls	4.7	4.8	4.7	4.8	4.8	3.2
Human Machine Interfacing (HMI)	4.6	4.4	4.6	4.5	4.3	3.1
DCS	2.6	2.8	4.2	4.7	4.2	1.7
Computer-Aided Design-Computer-Aided Manufacturing (CAD-CAM)	4.2	3.7	3.2	4.2	4.2	1.5
Supervisory Control and Data Acquisition (SCADA)	2.6	2.7	2.3	4.2	4.1	1.2
Robotics	2.6	2.8	2.3	2.3	2.4	4.2
Internet of Things (IOT)	2.3	2.6	2.5	2.3	2.4	3.4

*M-Manufacturing; FB-Food & Beverage; C-Chemicals; P-Power; CM-Cement & Metals; A-Academe

Table 2 reflects the result of the assessment of skills and competencies the industry are expecting their entry level workers in the plant settings as well as the perceived skills and competencies possessed by the students right after graduation. Most of the industries marked very high demands among the skills and competencies except for SCADA and robotics. This is obviously ascribed to non-applicability or this system which might be kept by third party maintenance thus, the responses were lukewarm. On the other hand, most of the students from technology-based programs responded fairly to their skills set which is indicative of their inadequate confidence of their craft. The skill set required by the industry at entry level differs to that of the students. Hence, a job-skills mismatch exist between the industry and the academe. Skill set that are poorly rated among industry and students are in the areas of SCADA and robotics which are attributed to inadequate applicability and less occupational demands in the industry. The varying mean responses might be validated using non-parametric test. Inferential statistics might be appropriate to determine the level of significant differences among responses from among survey participants. By subjecting this study to inferential test may result to a more precise data analysis that will produce compelling evidences to support better resource generation and allocation for a more innovative approach to teaching and learning.

Table 2. The composite Mean responses on skills competency qualification

Skills competency requirements	Mean Value Industry Classification* M	FB	C	P	CM	# S
Ability to analyze and apply basic electrical and electronics principles within the various industry applications	4.8	4.7	4.8	4.7	4.7	3.2
Ability to utilize, wire input & output devices, and program PLC using ladder diagram	4.8	4.8	4.7	4.8	4.8	3.3
Ability to analyze and apply basic instrumentation and control such as tuning and PID programming	4.2	4.6	4.7	4.7	4.7	1.5
Ability to utilize 2D and 3D CAD	4.6	4.6	4.2	4.2	4.3	2.4
Ability to set-up proper industrial Motor Controls	4.8	4.7	4.8	4.8	4.8	2.6
Ability to set-up and use computer networking/machine networking within the local area network	4.5	4.6	4.6	4.7	4.7	3.1
Ability to read and interpret manufacturing documentation such as blue prints, drawings diagrams, schematics and other relevant plans	4.8	4.8	4.7	4.7	4.8	3.2
Ability to design and implement various fluidpower system using pneumatics and hydraulics	4.6	4.6	4.4	4.6	4.7	3.2
Ability to set-up and use human-machine interface and utilize SCADA systems	1.9	2.2	4.6	4.8	4.5	1.2
Ability to set-up and program appropriate microcontroller for basic robotics for appropriate application	1.5	1.6	1.4	1.4	1.6	3.2

*M-Manufacturing; FB-Food & Beverage; C-Chemicals; P-Power; CM-Cement & Metals; #S-Student

3.2 Curriculum Review and Development

The process of curriculum review and development was jumpstarted with the conduct of industry-academe forum on current industrial trends and academic best practices to insure academic relevance as reflected in Figure 1 that shows the Continuous Quality Improvement (CQI) OBE Framework. Based on the inputs from the stakeholders, the identification of graduate attributes was undertaken looking into consideration the vision and mission of the university. There are six attributes of a USTP graduate which was articulated collegially by the curriculum committee of the university namely: thinking and reasoning, communications, diversity, collaboration, sustainability and specialized discipline. The program educational outcomes (PEOs) were then crafted that describes the USTP graduates characteristics three-to-five (3-5) years after graduation. Likewise, the program outcomes (POs) were anchored on the distinct differentiating characteristics in accordance to Washington, Sydney and Dublin Accords as shown in Table 3 where the "complex", "define and applied", and "wide practical" were clearly emphasized (IEA, 2013). POs are the occupational qualities of program graduates immediately right after graduation.

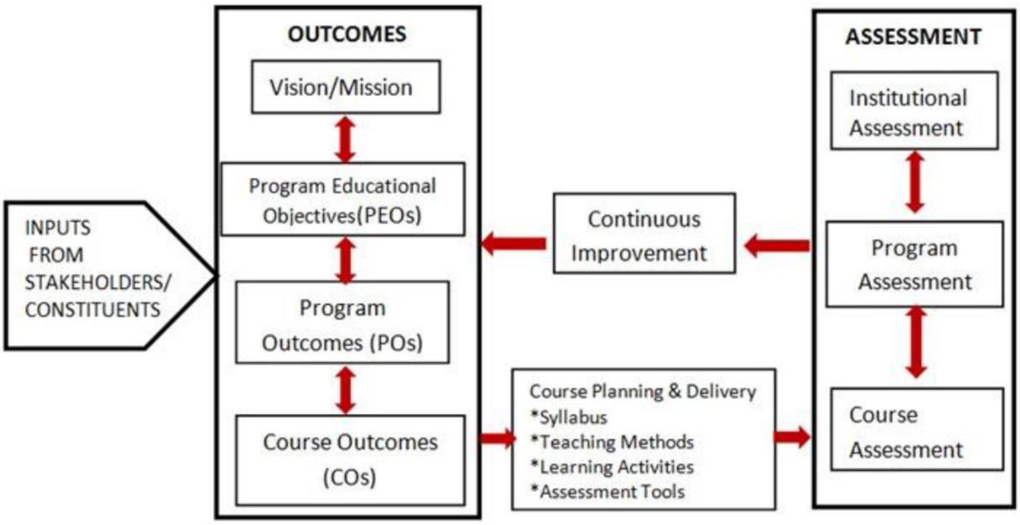

Figure 1. CQI OBE Framework

Table 3. A sample graduate attributes differentiating characteristics (Courtesy of IEA)

… for Washington Accord Graduate	… for Sydney Accord Graduate	… for Dublin Accord Graduate
Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization as specified in WK1-WK4 respectively to the solution of complex engineering problems.	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization as specified in SK1-SK4 respectively to defined and applied engineering procedures, processes, systems or methodologies.	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization as specified in DK1-DK4 respectively to wide practical procedures and practices.

There are thirteen (13) POs crafted for the BS in Electro-mechanical Technology (BSEMT) program of USTP which contain the institutional graduate attributes and the Sydney Accord differentiating characteristics:

a: Demonstrate innovative and critical thinking in the application and integration of knowledge in mathematics and science to solve technology and engineering problems through well-defined and applied systems to justify the appropriateness of the solution, both tangible and intangible new ideas or ways of approaching things to create possibilities and opportunities.

b: Identify, formulate, analyze and solve broadly-defined and applied technology and engineering problems through analytical tools and application of knowledge of diversity and multicultural competencies to promote equity and social justice in the community through shared responsibility for collaborative work and valuing the individual contributions made by each team member.

c: Design a system, component, or process to meet the desired needs within a well-defined and applied realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, in accordance to standards and work collaboratively and respectfully as member and leader of diverse team and community in sustainable development.

d: Conduct investigations, design and experiments, as well as to analyze and interpret data responsibly and sustainably on current economic demands at local, national and global levels in the face of broadly-defined and applied adverse circumstances and uncertainties.

e: Demonstrate expertise and articulate views, thoughts and ideas effectively using well-defined and applied modern enabling technology and engineering tools necessary for the practice in a specialized discipline of study.

f: Communicate ideas clearly through knowledge of contemporary issues in the development of quality human capital, technology solutions and enterprise to engage in well-defined and applied independent life-long learning at local, national, and global levels.

g: Understand the impact of technology and engineering solutions in the face of adverse circumstances and uncertainties through broadly-defined and applied education necessary for sustainable economic and environmental development in local, national and global context.

h: Understand professional, social and ethical responsibility in the application of diverse broadly-defined knowledge and multicultural competencies to promote equity and social justice in the community.

i: Function independently, collaboratively and effectively as individual, member or leader of multidisciplinary, trans-disciplinary and multi-cultural teams through well-defined and applied modern communication tools.

j: Communicate well-defined and applied ideas, perspectives, and values effectively, clearly and persuasively in English (and as much as possible local language and Filipino) as well as be able to listen and comprehend and write effective reports, design documentation, make effective presentations, and give and receive clear instructions.

k: Effectively demonstrate knowledge and understanding of well-defined and applied technology and engineering management principles as a member and leader in a team, to manage projects and in multidisciplinary environments.

l: Recognize the need for, and engage in life-long learning to discuss and demonstrate expertise through integration of ideas, methods, theory and practice in the latest development of well-defined and applied relevant technologies.

m: Able to think critically and creatively; and apply analytical and quantitative reasoning to address well-defined and applied challenges and everyday problems through participation and engagement in research and development aligned to local and national development agenda or goals.

The identification of courses were undertaken using two approaches. One is through benchmarking from existing curriculum and the using DACUM. USTP utilizes both processes to ensure that all aspects of curriculum development are captured. Apart from benchmarking, DACUM was used to technically extract the valuable inputs from the stakeholders using the "DACUM research chart". Figure 2 shows a screenshot of the DACUM research chart for BS Electromechanical Technology. The DACUM Chart reflected the duties and tasks inherent of the program to engage. These sets of duties and tasks are perceived to be one of the sources of references in the identification of subjects or courses. Likewise the identification of the necessary tools needed in the performance of each tasks are shown in Figure 3. As a result of the performance of duties and tasks, appropriate knowledge and skills are developed among students as depicted in Figure 4. The aforementioned DACUM process is a crucial determinants in course specifications apart from the relevant program benchmarking.

DACUM Chart for BS in Electro-mechanical Technology

DACUM Skill Rating Scale

1. Can perform some parts of this skill satisfactorily but requires assistance and/or supervision to perform the entire skill.	4. Can perform this skill competently with more than acceptable and/or quality and can teach the skill to others.
2. Can perform this skill satisfactorily but requires periodic assistance and/or supervision.	5. Can perform this skill most competently and/or quality and can efficiently replicate skill to others.
3. Can perform this skill competently without the assistance or supervision	

DUTIES	TASKS				
A. Repair Equipment	A1 Repair equipment	A2 Identify repair needs	A3 Troubleshoot equipment	A4 Acquire replacement parts, i.e. purchase, fabricate	A5 Replace parts
	1 2 **3** 4 5	1 2 **3** 4 5	1 2 **3** 4 5	1 2 **3** 4 5	1 2 3 **4** 5
	A6 Assemble repaired parts and perform tests	A7 Train machine operators, i.e. set-up, procedure, sequence	A8 Correct process, i.e. raw materials, environment, tooling	A9 Perform machine adjustments	A10 Verify repair
	1 2 3 **4** 5	1 2 **3** 4 5	1 2 **3** 4 5	1 2 3 **4** 5	1 2 3 **4** 5
	A11 Clean-up repair environment	A12 Return to production	A13 Document repair	A14 Report repair	
	1 2 3 4 **5**	1 2 3 **4** 5	1 2 3 **4** 5	1 2 3 4 5	1 2 3 4 5
B. Perform preventive and predictive maintenance	B1 Create a preventive maintenance procedure	B2 Schedule preventive maintenance	B3 Execute preventive procedures	B4 Modify preventive procedures	B5 Complete Preventive maintenance
	1 2 **3** 4 5	1 2 **3** 4 5	1 2 **3** 4 5	1 2 **3** 4 5	1 2 **3** 4 5

Tools, equipment, supplies and materials

- Multimeter
- Computers
- Power tools
- Hand tools
- Precision measuring devices
- Temperature sensors
- Pressure sensors
- Level sensors
- Flow sensors
- Inductive sensors
- Capacitive sensors
- Magnetic sensors
- Reed sensors
- Ultrasonic sensors
- Oscilloscope
- Function generator
- Microcontrollers
- MyRIO
- Programmable logic controllers
- Welding machines
- Augmented Reality Welding machines
- Cutting torch
- Milling machine
- Lathe machine

Future trends/concerns

- Continuing professional education/learning
- Learning retention
- Recruitment (HR)
- Data analytics
- Constant improvement
- Increasing complexity
- Constant changing technology
- Increased safety compliance standards
- Increasing certification requirements
- Increased multi-skilled requirements
- Environmental concerns
- Keeping abreast with old and new technologies
- Lack of appreciation
- Inadequate knowledge
- Language and cultural barriers
- Computer competency
- Diversity
- Global economy
- Combining job tasks
- Automation
- ICT competency

Acronyms

- PLC –Programmable Logic Control
- PPE - Personal Protective Equipment
- PM – Preventive maintenance
- EH&S – Environmental Health and Safety
- OSHA – Occupational Safety health Act
- NEC – National electrical Code
- PIC – Production Inventory control
- HVAC – Heating, ventilation, and air conditioning
- ISO – International Organization for Standardization
- EPA – Environmental Protection Agency
- OJT – On-the-Job-Training
- PID – Proportional-Integral-Derivative
- PI & D – Process Instrumentation Diagram
- OBE – Outcome-based Education
- PQF – Philippine Qualification Framework
- AQRF – Asean Quality Referencing Framework

Figure 3. Identified tools & equipment screenshot

- Office equipment
- Hydraulic power unit
- Hydraulic trainer
- Pneumatic system trainers
- Electro-pneumatic trainers
- Soldering irons
- Air Compressors
- Electric motors
- Servo motors
- Stepper motors
- Mobile robotics
- Multi-axes robotic arm
- Machine visioning system
- Flexible Manufacturing system
- Mechatronics system
- PID pneumatic systems
- Sensor technology systems
- Labview
- National Instrument Systems
- Visioning system
- Instrumentation & Process control Trainer
- Personal computers
- Industrial controllers
- GSM modules
- Cellular phone
- Compressors
- Filter-regulator-lubricator
- Relays
- Switches
- Overhead crane
- Boom lifter
- Communication radio

- Communication skills
- Attitude
- Godliness

General Knowledge and skills

- Welding techniques
- Communication skills
- Oral, written, email, foreign language, multi-lingual, sign language
- Computer skills
- Electrical
- Electronics
- Mechanical
- ICT
- Fluidpower technology
- Pneumatics
- Hydraulics
- Multi-tasking
- Drafting
- CADD
- CAD-CAM
- Machining
- Measurement
- Meter use
- Test equipment
- Troubleshooting
- Mathematics
- Physics
- Thermodynamics
- Mechanics
- Hand-tool operation
- Time management
- Safety practices

- TPM – Transformation of People and Machine
- CAD-CAM – Computer-aided Design – Computer-Aided manufacturing
- CADD – Computer-Aided Design and Drafting
- ICT– Information and Communications Technology

Worker Behaviors

- Flexible
- Persistent
- Good listener
- Team player
- Positive attitude
- Patient
- Can handle stress
- Open-minded
- Reliable
- Takes order well
- Inquisitive
- Can-do attitude
- Creative
- Alert
- Attentive
- Sensible
- Prompt
- Decisive
- Timeliness
- Ethical
- Consistent
- Diverse
- Loyal

Figure 4. Knowledge & skills screenshot

After the DACUM process, the faculty members of the College of Technology of USTP-CDO proceeded to undertake course inventory taking into consideration the K12 program, the relevant CMOs and the inputs from previous FGDs with industry representatives and other stakeholders. The output of the course inventory was the crafting of the program prospectus. One important aspect of the undertaking was the number of units that has to be offered in such a way that the technology program remains attractive not only for the local students but also for future international students. The number of units limit was pegged at 176 units for a four (4) year program.

The program prospectus was then subjected into mapping and equated to the program outcomes of the BS in Electromechanical Technology. Likewise, each course outcomes were also mapped with the POs using the indicators introductory (I), enabling (E) and demonstrating (D). The indicators were analyzed as to whether the courses specified are significantly required or disregarded. This COs to POs mapping were reflected in the syllabus as shown in Figure 5. The university agreed on a syllabus template across academic programs. One of the glaring features of the syllabus were the captured vision, mission, program educational outcomes

(PEOs) and the program outcomes (POs). Figure 6 shows the course outcomes (Cos) mapped with the program outcomes (POs). It must be noted that the syllabus content design is in consonance with the outcome - based education (OBE). Figure 7 shows the course coverage where COs, intended learning outcome (ILO), topics, teaching learning activities (TLA) and assessment tasks/tools are properly matched. In every CO, there might be more than one ILOs.

USTP

University of Science and Technology of Southern Philippines
College of Technology

SYLLABUS
Course Title: **ELECTROPNEUMATICS WITH PLC PROGRAMMING**
Course Code: **EMT 31**
Credits: 3 Units (2 Lec units; 1 Lab unit) – 18 weeks

USTSP Vision

A nationally-recognized Science and Technology (S&T) university providing the vital link between education and the economy

USTSP Mission

- Bring the world of work (industry) into the actual higher education and training of the students;
- Offer entrepreneurs of the opportunity to maximize their business potentials through a gamut of services from product conceptualization to commercialization;
- Contribute significantly to the national development goals of food security and energy sufficiently through technology

Semester/Year: 2nd Semester, SY 2018-2019
Class Schedule: Mondays 3:00PM-5:00PM; Fridays 9:00AM-12:00AM
Bldg/Rm no.: ITB/03-102

Prerequisite(s): Physics 1 & 2 (Mechanics & Heat, Electricity & Magnetism)

Co-requisite(s):

Instructor: **DR. RUVEL JONGKO CUASITO, SR., PECE**
Email: cuasitorj@yahoo.com
Mobile no.: 0917-431-8610

Consultation Schedule:
Bldg./Rm:
Office Phone no./Local:

I. Course Description:

The course covers the theory and operating characteristics of two hybrid systems. Covered in this course is the integration of electronics and pneumatics coupled by basic PLC programming as they relate to industrial automation.

II. General Objectives and Student Course Outcomes:

GENERAL OBJECTIVES

The general objective of learning pneumatics and its integration to electronics is to infuse learning the basic concepts and application of the technology to the real industry trends. The strategy of instruction delivery is carefully devised in such a way that its important components are deeply emphasized and absorbed by the students in particular.

STUDENT COURSE OUTCOMES

Students are prepared to design, develop, implement and evaluate relevant fluidpower enabling technologies using the skill set in pneumatics, electro-pneumatics and programmable logic control programming as it applies to industrial automation processes and human resource requirements in the industry.

Figure 5. Course syllabus screenshot

solutions.

Program Educational Objectives:

PEO1: To develop the learner as a holistic person who is knowledgeable, productive and self-reliant member of the society with social, economic and environmental responsibility.

PEO2: To equip students with appropriate knowledge and skills, proper attitudes and values towards work.

PEO3: To translate vocational interest and diversified occupational skills through the effective utilization of appropriate technology for people's economic sufficiency.

Program Outcomes:

a: Demonstrate innovative and critical thinking in the application and integration of knowledge in mathematics and science to solve technology and engineering problems through defined and applied systems to justify the appropriateness of the solution,

Course Outcomes and relationship to Program Outcomes:

Electro-pneumatics with PLC Programming Course Outcomes (CO) After the completion of the course, the student should be able to:	a	b	c	d	e	f	g	h	i	j	k	l	m
CO 1: Recognize, exemplify, and execute technical knowhow on the fundamental characteristics of pneumatic working elements as it applies to some logic functions in the industry.	I	I	E		E	I	I			E	I	I	E
CO 2: Describe, create and execute the necessary skill set in relay logic as it applies to electropneumatics and industrial controls.	E	E	D		D	E	I			E	D	E	E
CO 3: Describe, create and implement the necessary skill set in pneumatics and electropneumatics circuit design, implementation and evaluation in real industry application.	E	D	D		E	E	I			E	D	E	D
CO 4: Recognize, classify, differentiate, assess and create technical knowhow on fundamental relationship between relay logic and programmable logic control programming.	E	E	E		E	E	I			E	D	E	E
CO 5: Describe, compare, execute and create competence in design and implementation of electropneumatics and programmable logic control technology solutions.	D	D	D		E	D	I			D	D	E	E
CO 6: Describe, explain, apply and attribute practical knowledge on the applications of industrial automation enabling technologies in the industry and its necessary skill set requirements.	D	E	E		E	E	E			E	E	E	E
CO 7: Recognize, exemplify, classify, and generate skills to manage creative teams and project processes effectively and efficiently.	E	I	E			E	E			E	D	E	E

COs are consistent with the program outcomes as well as the College and University Mission.

Figure 6. Course outcome vs. program outcome mapping

both tangible and intangible new ideas or ways of approaching things to create possibilities and opportunities.

b: Identify, formulate, analyze and solve broadly-defined technology and engineering problems through analytical tools and application of knowledge of diversity and multicultural competencies to promote equity and social justice in the community through shared responsibility for collaborative work and valuing the individual contributions made by each team member.

c: Design a system, component, or process to meet the desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, in accordance to standards and work collaboratively and respectfully as member and leader of diverse team and community in sustainable development.

d: Conduct investigations, design and experiments, as well as to

III. Course Coverage:

Course Outcome (CO)	Intended Learning Outcome (ILO)	Topic/s	Teaching-Learning Activities (TLA)	Assessment Tasks/Tools
CO 1	**ILO 1.1** Recognize, understands, and analyzes varied pneumatic working elements' fundamental theoretical characteristics, physical profile and technical symbols.	The pneumatic working elements ✓ Pneumatic Supply ✓ Pressure Regulator ✓ Air Service Unit ✓ One-way Flow Control Valve ✓ 3/2 Directional Control Valve ✓ Pneumatically Operated Directional Control Valve ✓ Electrically Operated directional Control Valve ✓ Single Acting Cylinder ✓ Double - acting cylinder with stroke – cushioning at both ends ✓ Rotary Actuator	**TLA 1.1**: Lecture, class discussion, computer simulation, demonstration and laboratory activity	Quiz, Oral examination
	ILO 1.2 Apply and evaluate the various pneumatic working elements in accordance to its basic control concepts in the industry.	The pure pneumatic control ✓ Direct Control ✓ Indirect Control ✓ Dominant ON ✓ Dominant OFF	**TLA 1.2**: Lecture, class discussion, seat work, board work, homework, computer simulation and laboratory activity.	Quiz, recitation, computer simulation exam, Laboratory exam
CO 2:	**ILO 2.1** Recall, classify, and execute relay logic principles to	Relay Logic ✓ Logic Functions	**TLA 2.1:** Lecture, class discussion, seat work,	Quiz, recitation, computer

Figure 7. Course coverage screenshot

The review and development of technology-based curriculum process followed nine (9) phases namely: (1) industry-academe forum, (2) crafting the program "vision and mission" and "development of program educational outcome (PEOs), and program outcome (POs)", (3) "PEOs-POs mapping" and "POs-Program Indicators (PIs) mapping", (4) DACUM charting, (5) Course inventory, (6) Courses-POs mapping, (7) Course syllabi development, (8) Presentation of curricular output and (9) Submission to the BOR through the academic and administrative councils.

In the process of curriculum development following the DACUM and program benchmarking, new challenges confronts the industrial technology programs in the Philippines. The quest for quality education continue to rise up not only to secure affirmation from the industry, academic program accreditation bodies but also seeking international recognition via International Organization for Standardization (ISO), international accords and the ASEAN Qualification Referencing Framework (AQRF). Hence, the promulgation of the Philippine Qualification Framework was mandated by law through Executive Order No. 83 series of 2012 (TESDA, 2012). Figure 8 shows the PQF which is a national policy that describes the levels of educational qualifications outcomes. It is a quality assured national system for the development, recognition and award of qualifications based on standards of knowledge, skills and values acquired in different ways and methods by learners and workers of a certain country (TESDA, 2012). The educational levels are under the corresponding responsibilities of DepEd for L1 & L2, TESDA for L3 & L4 while CHED oversees L6-to-L8. The problem lies on Level 5, this is the gap that the University of Science and Technology of southern Philippines (USTP) is trying to address through this current initiative – the "Development of Technology-Based Programs towards the PQF".

Early discussions about the PQF was initiated by TESDA and USTP tapping the College of Technology to spearhead the study on curricular development that addresses L5 of the PQF. Since this is the level that represents the gap between technical education and skills development and the higher education, the need to strategize the offering of technology-based programs may be feasible addressing both L5 and L6. Level 5 will now be focused on the offering of Diploma courses within the first three years of a four-year baccalaureate degrees. This responsibility is placed on the shoulder of the College of Technology.

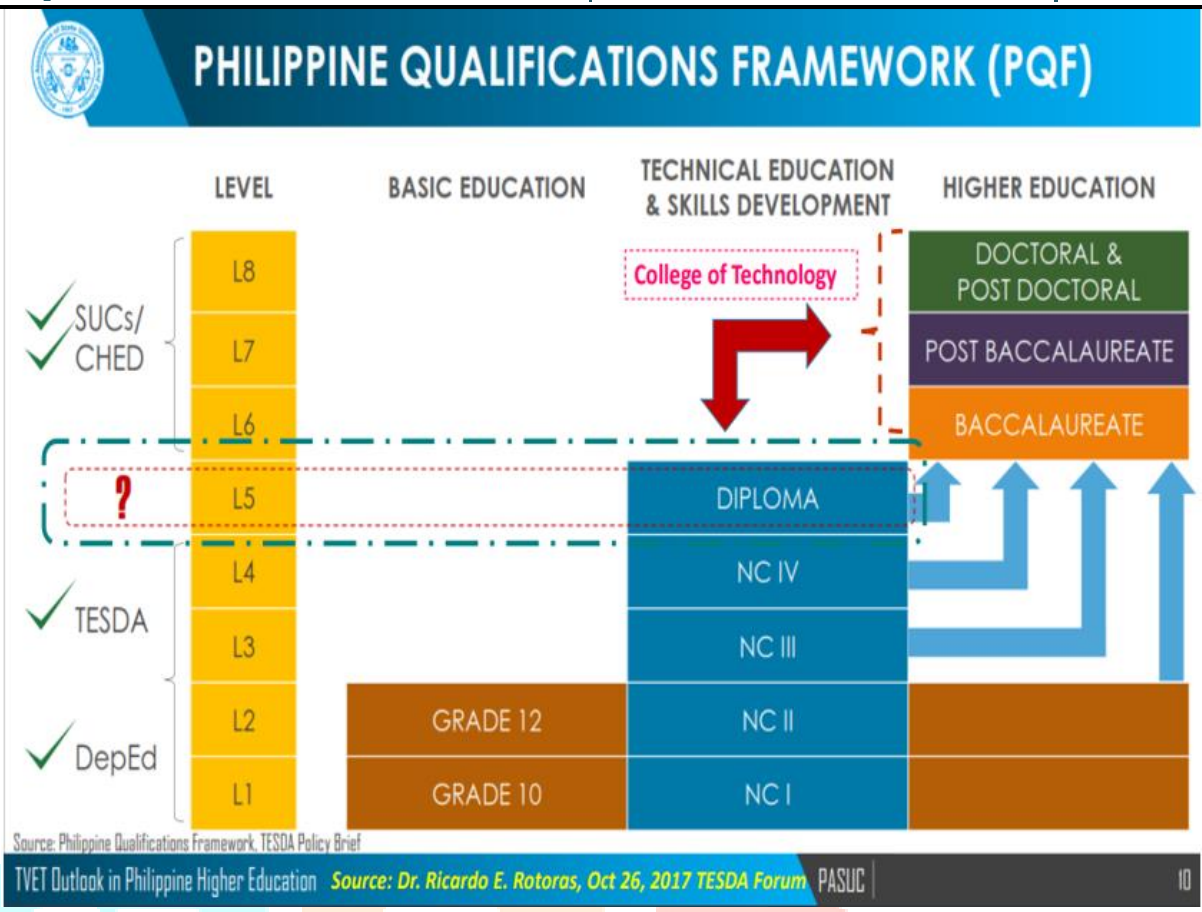

Figure 8. The Philippine Qualification Framework

The advent of PQF eventually leads to the development of the "technology program continuum" as shown in Figure 9 that describes the strategy of crafting a technology-based program in adherence to the PQF. It describes the input provided by the Senior High School (SHS) which is expected to have had taken the National Certification (NC 2). Under the Diploma program, each year has its own exit and continuing options. Students may opt to exit for employment purposes or proceed to the second year and onwards. Each year level under the diploma program has corresponding NCs – NC2/NC3 for 1st Year, NC3 for 2nd Year and Diploma for 3rd Year.

After the diploma or PQF-Level 5, the graduates may proceed to the following baccalaureate degrees in BS in Technology, BS in Engineering and BTVE. However, the graduates might be required to take bridging courses leading to their desired baccalaureate degree programs. Graduates from other academic and training institutions might undergo accreditation and/or bridging courses to assist the graduates in their transition towards the baccalaureate degrees.

There are five (5) baccalaureate degree programs that were approved by the USTP Board of Regents (BOR) namely: (1) BS in Electromechanical Technology, (2) BS in Electronics and Communications Technology, (3) BS in Energy Systems and Management, (4) BS in Autotronics, and (5) BS in Manufacturing Engineering Technology. Apart from these baccalaureate degrees, there were eight (8) diploma programs were develop in conjunction with OBE, DACUM, and Dublin accord standards. The diploma programs are: (1) Diploma in Mechatronics and Robotics, (2) Diploma in Electronics Systems, (3) Diploma in Telecommunications and Networks, (4) Diploma in Multimedia Systems Technology, (5) Diploma in Autotronics, (6) Diploma in Electrical Machines Control and Management, (7) Diploma in Power Systems Distribution with Eco-Design, and (8) Diploma in Mechanical Design and Fabrication.

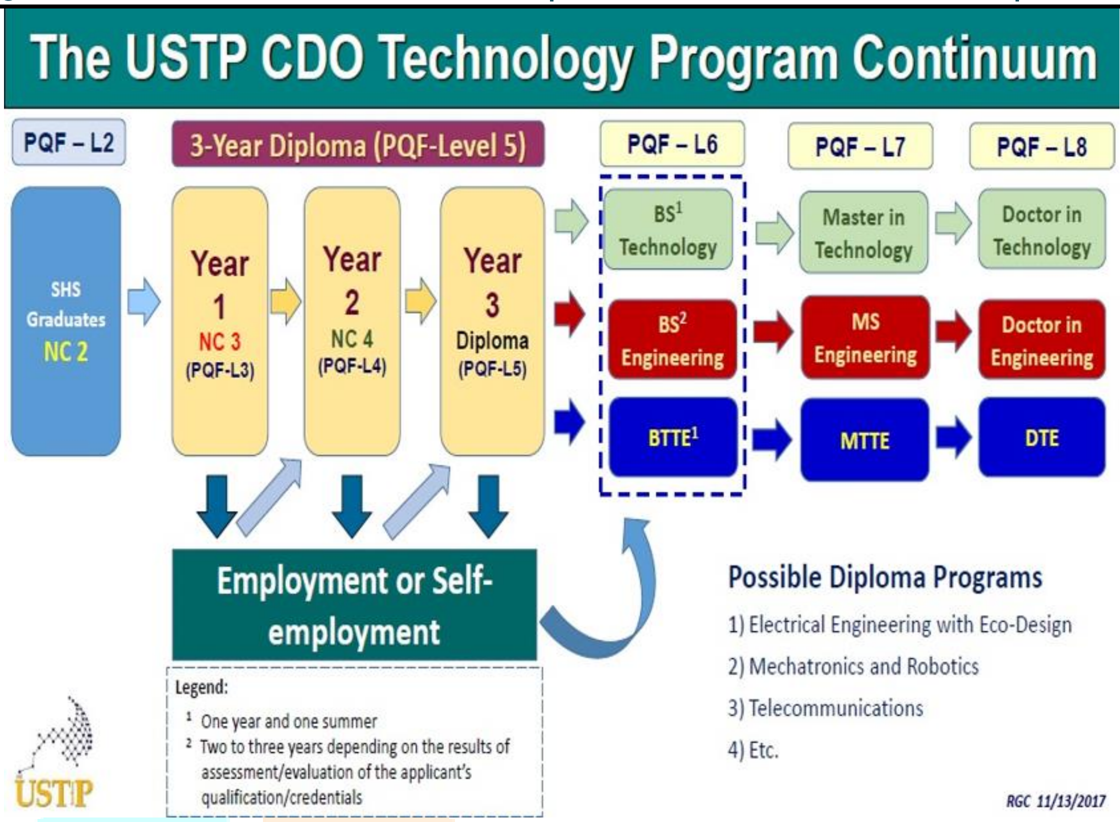

Figure 9. The Technology Program Continuum

The development of creative and innovative program offerings of USTP is mandated by law as per RA 10919 otherwise known as the USTP Law. The authority to offer the aforementioned technology-based programs lies on the highest governing body of the university – the BOR. However, in the light of the CHED directive to secure Certificate of Program Compliance (COPC) in adherence to CHED's PSG, all programs offered in USTP shall adhere to the COPC requirements through the USTP BOR via a request addressed to CHED Regional Office (CHEDRO) for possible endorsement to CHED Central Office. It must be noted that all technology-based programs of USTP are not covered with CHED PSG. It is perceived that with RA 10919, all these aforementioned programs are legal.

The outcome of this study was able to generate enrolment across the baccalaureate degree and Diploma programs shown in Table 3. It must be noted that BS in Electromechanical Technology (BSEMT) is the only baccalaureate degree that offers straight technology program. However, Diploma in Mechatronics & Robotics is under the turf of BSEMT. There are three Diploma programs under the BS in Electronics and Communications Technology (BSECT) namely: Diploma in Electronics Systems Technology, Diploma in Telecommunications and Networks and Diploma in Multimedia Systems Technology. Diploma in Autotronics is under the turf of BS in Autotronics. There are two (2) diploma programs under the BS in Energy Systems and Management, Diploma in Electrical Machines Controls and Management and Diploma in Power Systems Distribution with Eco-Design. Diploma in mechanical Design and Fabrication is under the responsibility of the BS in Manufacturing Engineering Technology. There were a total of 1069 and 925 enrollees of the aforementioned programs in the 1st and 2nd semester respectively which means that many students subscribed and appreciated the programs. USTP and TESDA Region X entered into a Memorandum of Agreement (MOA) covering the accreditation of relevant diploma programs offered by TESDA and accredited Training Institutes (TTIs) subject to evaluation. The MOA also covers cross-training and education as well as some provisions of shared resources and scholarships.

Table 3. Enrolment Distribution of Technology-based Programs

Name of program	1st Semester, SY 2018-2019	2nd Semester, SY 2018-2019
BS in Electromechanical Technology (straight program)	213	197
Diploma in Mechatronics & Robotics	143	120
Diploma in Electronics Systems	116	101
Diploma in Telecommunications and Networks	116	96
Diploma in Multimedia Systems Technology	117	98
Diploma in Autotronics	95	88
Diploma in Electrical Machines Controls and Management	113	98
Diploma in Power Systems Distribution with Eco-Design	79	66
Diploma in Mechanical Design and Fabrication	77	61
Total	1069	925

III. . RESULTS AND DISCUSSION

The conclusion of this study is based on the significant results of the study. As to the assessment of enabling tools in mechatronics, there were noteworthy observation of discrepancy of utility that leads to the assumption that not all enabling technologies are utilized by the industry. Its utility depends upon the kind process the industry is adopting and also depends on the kind technology deemed appropriate for its unique processing. There were commonalities among industry utilities and majority of them were highly adopted as indicated by the mean ratings which were very good except for some enabling tools that were not utilized for reasons of non-applicability and inappropriateness to their industry processes. Likewise, the skill set required by the industry at entry level differs to that of the students' due to the glaring mismatch in the enabling technology utility and inadequate training.

The DACUM process played a very significant role in the curriculum development. The university agreed on the curriculum review and development phases that was undertaken. All programs in the College of Technology were develop with OBE in mind in conjunction with Sydney and Dublin Accords and the PQF.

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BIOSKETCH

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