Digital Fabrication Laboratory to enhance Innovator for Creative Digital innovation in 21st Century

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***Abstract*—'Thailand 4.0' is an economic model which is driven by innovation. Ministry of Digital Economy and Society had constructed a plan called 'Thailand 4.0' for the digital development to improve Thailand's economy and society. And, because Thailand is facing a problem of insufficient human resources for digital field, it is necessary to rush the development of human resources for digital field from primary school to high school to satisfy the needs of labor markets in scientific field. Hence, the Institute for the Promotion of Teaching Science and Technology had developed a project competition for fabrication lab in order to let Thai youth learn different engineering skills and improve innovative skills. The mentioned engineering project competition consists of 1) modern technology such as 3D printer, laser cutting machine and computer numerical control machine (CNC machine), 2) a process that creates creativity and innovation, and 3) innovators community in the area and fabrication laboratory network to lead Thai youth to be innovator by the integration of digital innovation to create new innovation in the future.**

Keywords; Innovator ; Invention ; Digital Fabrication Laboratory

I. INTRODUCTION

In 2559 B.E., Thai government wanted to stabilize economy of the country by issuing a policy that introduced a model called 'Thailand 4.0' in order to change the economic structure towards 'Value-Based Economy' [11]. Hence, the government of Thailand assigned Ministry of Digital Economy and Society to construct a social and economic plan called 'Digital Thailand 4.0' which helps Thailand to invent and utilize digital technology efficiently, and creates the potential to improve basic structures of innovation, information, human assets and other resources that lead the society and economy development to country's 'security, wealth and sustainability' [1] by the contribution of creativity knowledge, innovation, science and technology [12]

As a consequence from the execution of aforementioned policy, digital human assets were insufficient. Therefore, education affairs need to accelerate the development of digital human assets from primary school level to secondary level in order to satisfy the labor markets of science, technology and innovation fields. Thus, The Institute for the Promotion of Teaching Science and Technology has started a project called 'Fabrication Lab : FabLab' for Thai youth to acquire engineering skills in different aspects such as creativity, designing and masterpiece creation, including innovator skills [13] which are basis for Thai youth to invent digital technology innovation in the future. Furthermore, the mentioned Fabrication Lab is able to support learning skills in the 21st century that focuses on youth's practical knowledge.

II. FABRICATION LAB

Fabrication Lab is a small laboratory that is surrounded by new studies which motivate students to be creative, and able to work and study together [15]. Fabrication Lab is also a place where engineering tools (both software and hardware), devices and different materials are gathered [5] to support youth with their designing, practicing, testing, developing, fixing and creating creative concrete masterpiece by utilizing imagination and idea with basic technology [18]; [10].

Moreover, Fabrication Lab is stated to be a classroom that supports education in 21st century which improves 21st century skills acquiring by starting a student-oriented activity [17] that requires 3 important factors: 1) modern tools, 2) creativity and innovation supporting procedures, and 3) innovator communities in both local area and worldwide Fab Lab network [18]. The mentioned 3 factors are related to Assessment and Teaching of 21st Century Skills (ATC21S). Assessment and Teaching of 21st Century Skills proposed that future skills can be divided in to 4 categories: 1) Creativity, Problem Solving and Idea Learning, 2) Interaction and Co-working, 3) Efficient Tool Utilization, and 4) Local and Worldwide Participation [16].

Benefits of Fabrication Lab

1. Student and youth will acquire advance technology knowledge.

2. Student and youth will be indoctrinated to be a part of community.

3. The creativity and innovation of student and youth will be developed.

4. Student and youth will join 'Innovator Community' that increases the opportunity to utilize talents of each individual.

Digital Technology of Fabrication Lab

Fabrication Lab consists of 3 digital technology basis [19]:

1. '3D Printing' is a process that constructs three-dimensional object by continuously raising the layer of object until it is completed following a created model in the program. According to the electronics information [21], three dimensions of 3D Printing are width (x), length (y) and height (z). There are several types of 3D Printing as followings [2]

1.1 'Binder Jetting' is a 3D Printing process that sprays binders on material powder to solidify the object. Then, the roller is used to fill material powder to add layers on the object.

1.2 'Directed Energy Deposition' is a manufacturing process that sprays metal powder or applies metal wire on object, and provides thermal energy to melt metal components in order to continuously compact object's layers.

1.3 'Light Photo Polymerization' is a process that changes the liquid state of photopolymers in the container to solid by the use of light from projector or laser engraving machine.

1.4 'Material Extrusion' is a process that sprays semi-solid substance or melted material to create layers on the object.

1.5 'Material Jetting' is a process that sprays photopolymers on the object, and shoots light to solidify photopolymers.

1.6 'Powder Bed Fusion' is a process that exerts heat from laser light or electron beam on material powder such as metal or plastic powder to melt it, and let it cool down to bind as an object. Then, a roller is used to add material powder to increase the layers.

1.7 'Sheet Lamination' is a process that glues layers. Then, the filaments are repeatedly cut into shaped layers until the object is created. Another procedure for this process is binding metal sheets together by the use of ultrasonic wave, then using metal cutting head to cut the exceeding piece.

2. 'Laser Cutters' is an accurate and fast processed high quality tool that is used to cut object, especially the complex structured material. The laser cutting process exerts heat from beam on object to melt the heated area, then the object is cut smoothly into pieces. There are two kinds of laser cutters; hand-operated cutting, and Computer Numerical Control (CNC) cutting which is the cutting process is controlled by computer [14].

3. 'Computer Numerical Control: CNC' is referred to a method of controlling several machines by the use of software embedded computer which speeds up the production to punctually produce mass amount of precise pieces [6]

3.1 CNC router and CNC Engraving machines are suitable for cutting, carving and piercing 3D arts, object, wood, plastic, acrylic and foam. Moreover, these machines can be used with metal material such as steel, brass, copper and aluminum.

3.2 CNC Plasma machine is a suitable for all types of metal works, especially thick metal with the width less than 25 mm.

3.3 CNC Mini is an engraving machine that is specialized in small projects such as non-metal works.

3.4 CNC Waterjet cutting machine uses high pressure water jet to cut wide ranges of materials such as stone, tile, leather and metal, without losing the material's attributes from thermal cutting. This machine can cut up to 100 mm. width of object. Thus, it is commonly known to be able to cut all kinds of materials.

Fabrication Lab is a small laboratory that collects digital technology devices including both hardware and software for developing youth and student to be innovator.

III. INNOVATOR

Innovator is referred to educated venturesome who likes to create innovation. Innovator is also a person who can adapt complicated techniques (technological techniques) to their works. Furthermore, innovator can connect his/her idea with the issues, and get ready to face the unpredictable situation while developing innovation. These skills are essential since they can be used to improve and invent great innovation that produces beneficial goods [20]; [23].

Innovator can be classified into 4 types as followings [3]:

1. Gatekeeper – an innovator who gathers and sends appropriate data
2. Idea Generator – an innovator who is always creative
3. Coach – an innovator who encourages new idea
4. Godfather – an expert innovator who is successful to invent innovation

Additionally, [7] also classified learning innovator to 4 groups as followings:

Group 1 or 'Star' is a group of people who have characteristics of sustainable innovators, because these people are developed to increase their education innovation capability for advance sustainable innovation management.

Group 2 or 'Fireworks' is a group of people who are in a level of 'creator' since they are lack of sustainable innovator attributes. Although, advance learning potential of this

Innovator group is developed, the group is lack of sustainable innovation management idea and understanding.

Group 3 or 'Candle' is a group of operators who are specialized in works. However, they are lack of innovative creativity. People in this group are intermediately trained to improve their 'innovator potential' in order to understand and use the concept of high-level sustainable innovation management.

Group 4 or 'Match' is a group of workers who work and act according to their orders and responsibilities. People in this group are not trained to increase their skills and abilities towards innovation, and they are taught only the foundation of sustainable innovation management concept.

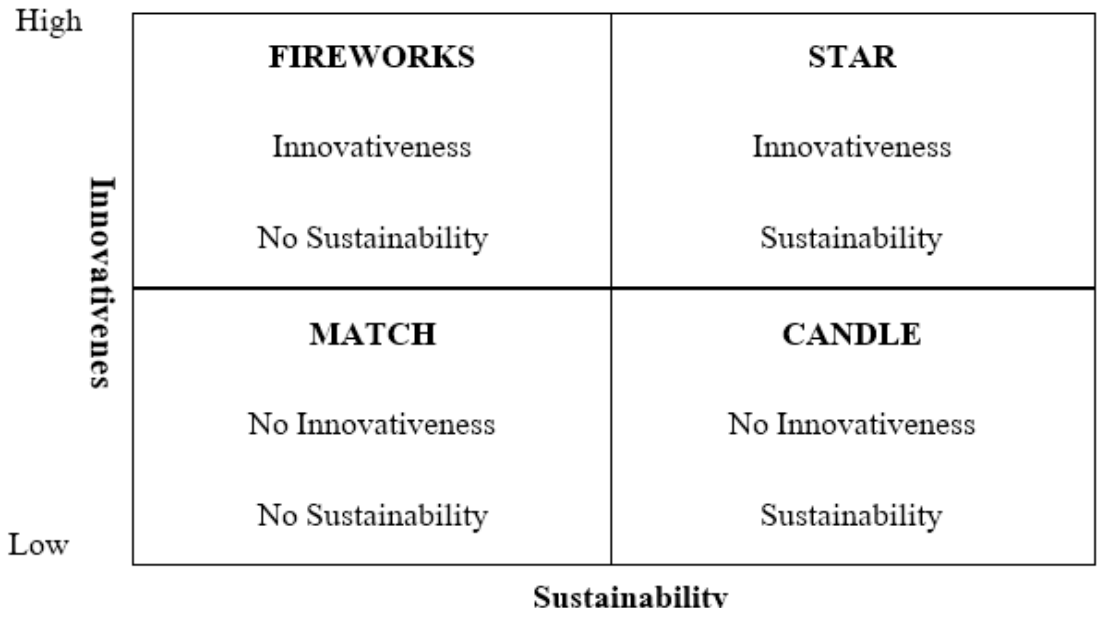

Figure 1. The Relationship of Innovator's Innovation Management and Ability

Characteristics of Innovator

The basic characteristics of innovator are as followings [4]; [9]

1. Associating – an important skill that is necessary for creative invention. This skill helps innovator to connect issues without adding irrelevant things. This skill can be acquired from experiences that widen the perspectives of innovator.
2. Questioning – a skill that encourages innovator to proceed his/her thinking process continuously, especially solution finding.
3. Observing – a skill that helps innovator to obtain important information and new opportunities since this skill involves behavioral observation that provides details for new idea and concept.
4. Experimenting – a skill that gives opportunities and possibilities for new invention. This skill is the combination of guessing and learning by correcting mistakes.
5. Networking – an interaction with other people in different fields to exchange knowledge, experiences and solution of issues.

Innovator is a person who utilizes skills and knowledge to create innovation in 21st century.

IV. DIGITAL INNOVATION

Characteristics of Digital Innovation Acceptance

Roger (1983) stated that there are 5 characteristics of digital innovation acceptance as followings:

1. 'Relative Advantage' is seeing benefits that are related to innovation users
2. 'Compatibility' is seeing that innovation is compatible with beliefs, values and cultures of innovation users
3. 'Complexity' is the opinion of innovation users towards innovation whether it is difficult to use. If the innovation is convenient and easy to use, innovation users are more likely to accept it rather than the complex one.
4. 'Trialability' is testing innovation.
5. 'Observability' is observing the success of innovation execution.

Characteristics of Digital Innovation

There are 3 particular characteristics of digital innovation as followings [22]:

1. 'Program Reproducibility' is the characteristics that enables digital devices to operate variously, for example, distance calculation, word checking, video editing and website searching.
2. 'Data homogeneity' is analog signal (a set of binary number such as bit) converting by the use of digital devices. Digital content such as video, message and picture can be stored, processed and displayed by using digital devices and same networks. Unlike analog data, digital data is gathered from different sources and can be combined to other digital data to provide various services that widens the limitation of goods and industry. Thus, data homogeneity together with new media help to separate contents from the media.
3. 'Digital Technology Referring' is referred to the demand of digital innovation to use digital technology like computer which positively causes the network to broaden digital innovation in order to create and use digital devices for both

service and content networks. In addition, digital innovation helps to reduce barriers related to learning budget, accelerated rate of extension, and the raise of innovation efficiency and prices. Thus, this helps more people to access new innovation.

V. SUMMARY

Digital Fabrication Laboratory is a classroom that supports the education of student and youth in 21st century. Engineering Digital Fabrication Laboratory helps to create Innovator 4.0 from student and youth development. Additionally, it motivates student and youth to study science, technology and innovation in higher education. Digital Fabrication Laboratory is also a place where human resource is trained to be ready for 'New S-curve' model from Thailand 4.0 policy. Furthermore, it encourages, develops and creates new entrepreneur who is driven by digital technology together with increasing competitive capability of Thai industries in world markets

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