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Key Elements for Development of Translational Education for Chemical Engineering Student

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Abstract: Despite the essential role of 3D printing technology in sustainable industrial development, most of the local university is yet to be fully equipped with the suitable instrumentation in providing a facility to researcher, academics and student. This complication was highly associated with the limited knowledge of additive manufacturing. Besides, the working scopes of 3D printing technology in chemical engineering not merely involving with basic digital design, but to the extend of complex high-end products, which requires a highly skilled chemical engineering student. Thus, the 3D printing technique can provide a complex structure which capable to enhance chemical engineering student visualization. Therefore, the purposes of this study are to study and accommodate a prototyping facility by fabricating a digital design and up to a complex prototyping industrial design. These combination techniques offered a precise prototyping model for process instrumentation analysis and design overview. Additionally, with the ease of projecting educational materials, academics will be able to enhance the visual, auditory, and kinesthetic approaches in a classroom activity. Moreover, the potential of this technology as a viable route to the fourth industrial revolution will be a key starting point in establishing translational research and expanding the pool of talent at the university level.

Keywords: *3D printing, Chemical engineering, Prototyping, Translational education*

1. Introduction

Transformation in the education system is inevitable to sustain strong economic growth and spurring investment in a country. The education market structures will shape the behavior of the participants in the market that give an effect towards achievement and productivity [1]. Whereas, the Malaysian commitment integrated with the target under the Sustainable Development Goal 4 (SDG4), ensures inclusive and equitable education and promotes lifelong learning opportunities for all by 2030. Hence, the adaptation of 3D printing technology also can be integrated with SDG4 targeting to improve quality education on B40 students. The education of the children from this group is also affected due to the household income [2].

The technological advancement through Industrial Revolution 4.0 (4IR) has addressed 11 elements which including 3D printing technology as one of the main

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elements [3,4]. Therefore, to meet the industrialized world, the education field also must be in line with the needs in technology and equip these students for better skill and improve understanding without using extra cost via integration of 3D printing and Industry 4.0 into course learning outcomes as an initiative for bringing student interest to digital design and enhance their soft skills [5].

Hence, the embracement of 3D printing technology in education is expanding as a tool that is found to take advantage of their functionalities to imitate for the wider adoption in technology [6-8]. Hands-on learning is designed to promote deep conceptual understanding, resulting in the great achievement of students in the 21st century. In an association of education system, there are plenty of additive manufacturing technologies was developed, however, 3D printing is the economical tool that can be used for the fabrication of advanced prototypes and final products [8].

The learning path is also designed for the student project where students must be able to explore the environment through inquiries and problem solving related to the real world. Students learn to become synergetic and adequately engage in problem-solving from the designed project-based learning by thinking creatively and innovatively towards lifelong education, communication skills, and collaboration. The translational research through industrial design and prototyping facility will provide a different approach in utilizing 3D printing technology. These project scopes are comprising of expanding 4IR through learning aid in chemical engineering education, a technological feasibility study in translational research and the development of recycling and biodegradable polymer for 3D printing technology.

The connectivity of each activity is presented in Fig. 1. The first scope of this project is to improve the academics approach in higher learning education. In general, the current course learning outcome (CLO) in the chemical engineering program can be enhanced through 3D printing technology. As an example, the CLO for Final Year Design Project which requires the student to illustrate a 2D piping and instrumentation diagram (P&ID) can be used as the main platform. Through 3D printing technology, students can produce their design with a precise scale of designated instruments for better visualization of the overall design (See Fig. 2). Moreover, the fabricated models can be disassembled and re-utilized by the next batch for sustainable education.

With the ease to projectile an educational material, academics will be able to enhance the visual, auditory, and kinesthetic approaches in a classroom activity. Moreover, the potential of this technology as a viable route to the fourth industrial revolution will be a key starting point in establishing translational research and expanding the pool of talent at the university level. Using a 3D printed model, the risk of an up-scaling project can be reduced by identifying multiple design options and controlling the risk before scaling the entire process.

In this study, a new industrial design and prototyping facility program will accommodate the necessity of learning aid for complex visualization, especially in the chemical engineering program. In-depth analysis for prototyping design using additive manufacturing technology will be a starting point in translating research output from lab-scale and expecting as the main reference in developing industrial design at the national level in the near future.

2. Method

The printed chemical design plant (piping and instrumentation) will be printed in assembling and dissembling units at a specific scale ratio of the actual industrial plant (see Fig. 2). The color of each unit can be coded by printing color and can be tagged at different parameters of the actual plant (material uses, type of reactor, etc.). Students will be given the task of producing a complex detail of the reactor and presented in actual engineering models. The complex design will require stereolithography 3D printed resin based for higher resolution. While 3D printed models which can be assembled and dissembled will require fused deposition modeling (FDM) 3D printer. The additional detail such standard piping and instrumentation can be added with hazard identification (see Fig. 3).

Teaching modules will be developed according to the 3D printed objects as hands-on and project-based learning for each of the objects. The module will embrace on lesson summary, learning objective, teacher preparation (materials, parts needed and assembly method on the 3D object), designing student activities (theory or concept, history, problem, tasks, testing and evaluation, activity schedule and reflection) and assessment (formative and summative).

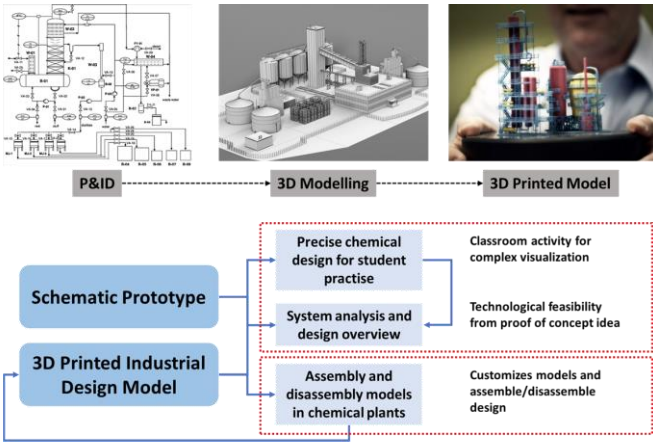

Figure 1: Conceptual design for project connectivity on the 3D printer facility

The designing process will be used Autodesk Fusion 360 (educational license) as the 3D modelling software. At the end of the process, the stereolithography (STL) file will be generated for printing purposes. All the designed objects will be saved in STL files where it stores information about the 3D models. These files will be used to print the objects. The whole designing and printing processes will involve the students.

The complex design of the instrumentation unit will be 3D printed at the precise level for the analysis. The multiple designated units can be printed as a comparison and technical feasibility study. The novelty of fitting the integrated process will be playing a major role in prototyping research outputs. While the 3D printing of the overall chemical process plant can be used as the main reference in the identification of hazard and risk assessment and determine control (HIRADC) for an up-scaling final design project.

3. Results and Discussion

The cost of operational work prototyping from conventional extrusion, casting polymer technology to additive manufacturing was significantly high in the past decade. Recently, 3D printing has become an affordable prototyping instrument that can be exploited for research and education. However, the scopes of 3D printing are mostly associated with the high-end product which requires a highly skilled professional credential.

The use of 3D print in education becomes practicable as it can be a tool to translate and deliver knowledge. As an example, students in Chemical Engineering Programme are compulsory to take part in the Process Plant Design Project. Students require to complete their final design components from process design, safety, control, contamination control, and waste treatment to good manufacturing practice and economy. One of the final assessments is presented through the fabricated chemical plant based on student creativity either from craft or recycle material. However, precisely forms a structure model, especially for the main instrument, is often difficult to construct.

While, in research and development, the technological feasibility of research outputs is always missing at the university level. This became a major drawback during upscaling and industrial approaches. In current practice, up-scaling the laboratory research scale to pilot-scale required higher costs and unpredictable results. While without proper analysis, especially in a specific design, the industry is not able to see the benefit of the developed products. A precise prototyping model for process instrumentation analysis and design overview. Eventually, the full operational 3D facility is expected to manifest a multitude of ideas and perfect numerous years in developing research extensively.

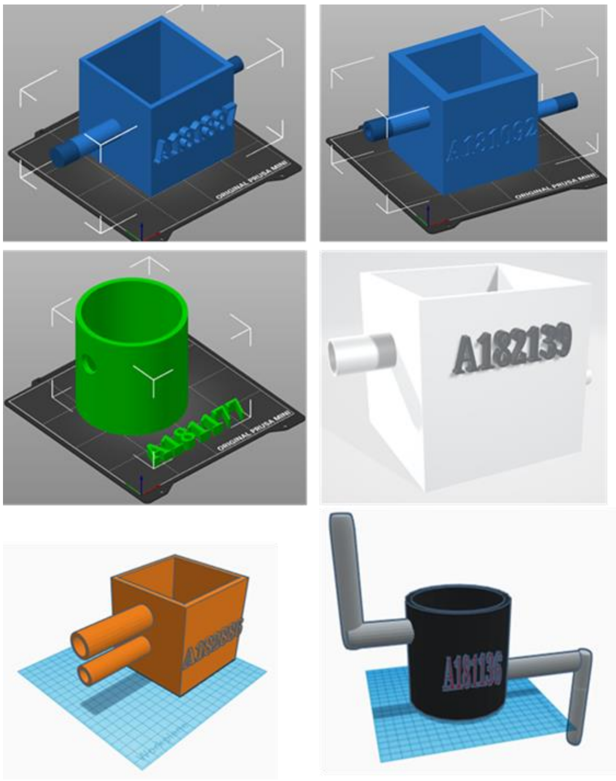

Figure 2: Conceptual design for project connectivity on the 3D printer facility

The translational research through industrial design and prototyping facilities provides a different approach in utilizing 3D printing technology. These project scopes are comprising of expanding 4IR through learning aid in chemical engineering education, a technological feasibility study in translational research and the development of recycling and biodegradable polymer for 3D printing technology.

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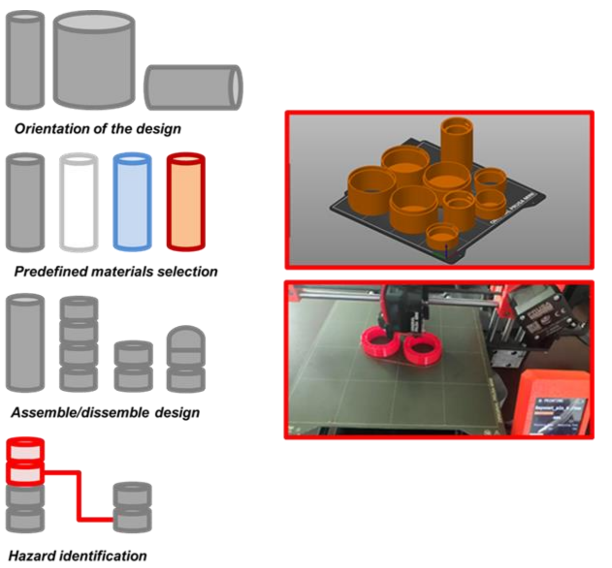

Figure 3: Conceptual design for project connectivity on the 3D printer facility

The designing process is focusing on digital designing using Autodesk Fusion 360 (educational license) as the 3D modeling software. At the end of the process, the stereolithography (STL) file are generated for printing purposes. All the designed objects were saved in STL files where it stores information about the 3D models. These files will be used to print the objects. The whole designing and printing process involved the student's collaboration as a student activity.

The complex design of the instrumentation unit is 3D printed at the precise level for the analysis. The multiple designated units can be printed as a comparison and technical feasibility study. The novelty of fitting the integrated process will be playing a major role in prototyping research outputs. While the 3D printing of the overall chemical process plant can be used as the main reference in the identification of hazard and risk assessment and determine control (HIRADC) for an up-scaling final design project. The printed chemical design plant (piping and instrumentation) are printed in assembling and dissembling units at a specific scale ratio of the actual industrial plant (see Fig. 3).

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3. Conclusion

This work shows a possible approach to a new industrial design and prototyping facility program which accommodates the necessity of learning aid for complex visualization, especially in the chemical engineering program. In-depth analysis for prototyping design using additive manufacturing technology will be a starting point in translating research output from lab-scale and expecting as the main reference in developing industrial design at the national level in the near future.

4. Acknowledgements

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