INDUSTRIAL REVOLUTION 4.0 INTEGRATION IN ENGINEERING EDUCATION – READINESS CASE STUDY OF DIPLOMA IN MECHANICAL ENGINEERING PROGRAM

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ABSTRACT - The effect of Industrial Revolution 4.0 (IR 4.0) demands changes not only in technical education but also education in general. As such, profound changes are necessary in major aspects ranging from content delivery to the structure and management of the education providers. The aim of the research is to develop a preliminary model to assess the readiness of the engineering education setup in incorporating IR 4.0 agenda within the spheres of syllabus content, management and delivery of the engineering programmes for tertiary education in Malaysia. The research methodology approach include an investigation through a questionnaire survey of four identified dimensions including "Organisational Structure & Management", "Teaching & Learning in Education 4.0", "IR 4.0 Student's Literacy" and "Technological Support & Availability". Overall, within the defined dimensions, 16 constructs were assigned in order to assess the Engineering Education readiness in incorporating IR 4.0. A case study to assess the readiness model was conducted on a small mechanical engineering program setup running diploma program run by UTMSPACE. The preliminary initial findings indicate that the readiness model could be applicable with further enhancements in assessing the readiness of IR 4.0 in engineering education setup.

KeywordsIndustrial Revolution 4.0; Readiness Model; Engineering Education

1. INTRODUCTION

Conceptually, IR4.0 can be summarised as integration, optimization, service oriented and interoperable manufacturing process correlated with algorithms, big data and high technology. Various research and publications in IR4.0 as surveyed by Lu (2017) fall upon the various categories ranging from concepts, cyber physical system (CPS), interoperability, key technologies and applications of Industry 4.0. In maturity studies, various models are available with example from Schumacher, Erol and Sihn (2017) who proposed a model in their studies involving manufacturing enterprises. Such model could serve as guidelines towards the intended studies of readiness from the perspective of engineering

education providers. In terms of addressing the challenges and critical needs of IR 4.0 in education, the Higher Education Ministry of Malaysia has introduced a range of initiatives (NST, 2018). Future teaching and learning environments need to consider the changes in organisational structures, teaching methods and learning concepts so as to fully prepare future engineers in the ever changing professional outlook. Change of teaching methods and learning include new teaching concepts such as flipped classrooms, or blended learning that reverses the traditional learning environment by delivering instructional content, often online, outside the classroom; new teaching and learning infrastructures such as equipment for virtual worlds and increased computing capacities; digital rights management and the shift from presence learning to distance learning (Jeschke, 2015). It can be assumed that virtual environments bear a huge potential to support the student lifecycle by situated learning, problem based learning and immersion as a key resource for high transfer achievements of developed knowledge and skills (Richert et al, 2015).

2. MATERIALS AND METHODS

The readiness of an educational setup in embracing IR4.0 is the current state at which the internal and external conditions within the setup support the various basic concept of IR4.0 such as horizontal and vertical integration of various systems and its associated cause and effect on engineering education.

The methodology in developing the preliminary readiness model includes three phases. An initial phase is the understanding of domains and disruptive nature as well as exponential effect of IR4.0 and identifying the causes and effect on engineering and technical education as well as literature search on readiness model. In this research, the preliminary model is proposed based solely on the extensive literature reviews. Initial concept of the structure of the preliminary readiness model would include readiness level from 1 to 5 where 1 is to be the lowest, the dimensions whereby in this case four is proposed, mode of assessment will be via questionnaire and finally mode of representation is in the form of numerical presentation visually via radar charts.

In phase two, the development of the overall initial readiness model specific towards engineering education include the readiness items and dimensions, levels and their characteristics were identified. A total of eighteen items or constructs were identified and were unequally grouped into four dimensions.

In the third and final phase, the preliminary model is based and tested on an engineering setup running Diploma in Mechanical Engineering run by UTMSPACE. The assessment is based on questionnaire surveys involving the items, dimensions of the proposed initial readiness model.

2.1 Preliminary Readiness Model

The proposed initial model consists of 18 items or constructs which are group into four dimensions with some overviews and exemplary items shown in Table 1.

Table 1. Dimensions and Readiness items of the preliminary Model

Dimensions	Readiness Item
Organisational Structure & Management	*Technology Roadmaps, Pathways for student re-engagement, Industry- Education partnership, Application of Key technological areas in curriculum, New pilot program*
Teaching & Learning in Education 4.0	*Innovations within teaching ecosystems, Higher thinking skills, Deeper learning techniques, Application of Creative technologies,*
Students' Literacy	*IR4.0 Concepts, Exponential Technologies, Impact of IR4.Technologies, Introductions of IR4.0 concepts in curriculum,*
Technical Supports & Availability	*Current technologies, Continuous financial support, Relevant Technologies, Competencies in handling IT issues, Capacity and Capability in Updating Technology*

Each readiness item undergoes various level of readiness with 1 describing a complete lack of attributes towards incorporation of IR4.0 concepts in engineering education while level 5 represent the state of arts readiness.

Evaluation of readiness within the small setup of Mechanical Engineering course under the Engineering Department of Centre for Diploma Studies, SPACE is conducted by using a standardised questionnaire consisting of one closed-ended question per readiness item. Each answer is in the form of Likert scale reaching from 1 – "not distinct" to 5 – "distinct". Table 2 show an example of an item Technology Roadmaps in this case for dimension Organisational Structure and Management.

Table 2. Example of an item measuring a Dimension

SECTION B: Organisational Structure & Management

11. **Do you use the technology road-maps of industrial sectors embedding IR 4.0 for the planning of your curriculum development?** *
Mark only one oval.

	1	2	3	4	5	
Not implemented	◯	◯	◯	◯	◯	Fully implemented

Measurement of understandings of the concepts of IR4.0 and the causes and effect on engineering education from all respondents were also made in order to gauge the current understandings in order to increase the accuracy of the questionnaire representability and accuracy of the readiness model. Finally, a readiness assessment at first level, were calculated for each items by determining the weighted means for every items within each domain and depicted in a radar chart.

3. RESULTS AND DISCUSSION

The results of a case study involving a Diploma in Mechanical Engineering program under an Engineering Department, SPACE, Universiti Teknologi Malaysia are presented. This small department were chosen for the initial pilot study for convenience in order to test the preliminary readiness model.

The results of the questionnaire were represented in a radar chart for each domain with a sample as shown in **Figure 1**.

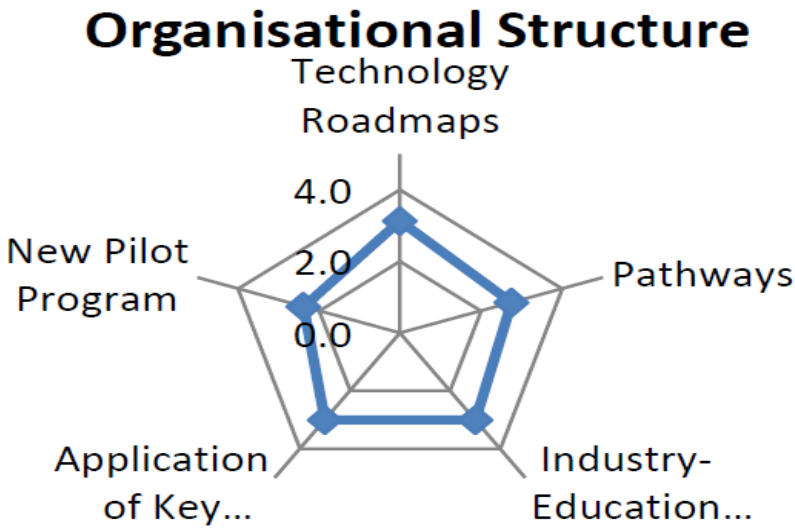

Figure 1. Sample of Radar chart showing results for dimension Organisational Structure

Finally, the readiness model in the four dimensions is depicted and visualised by means of Radar chart as shown in Figure 2. This will depict the current perceived level of readiness in incorporating IR4.0 in the engineering education provided for the case study.

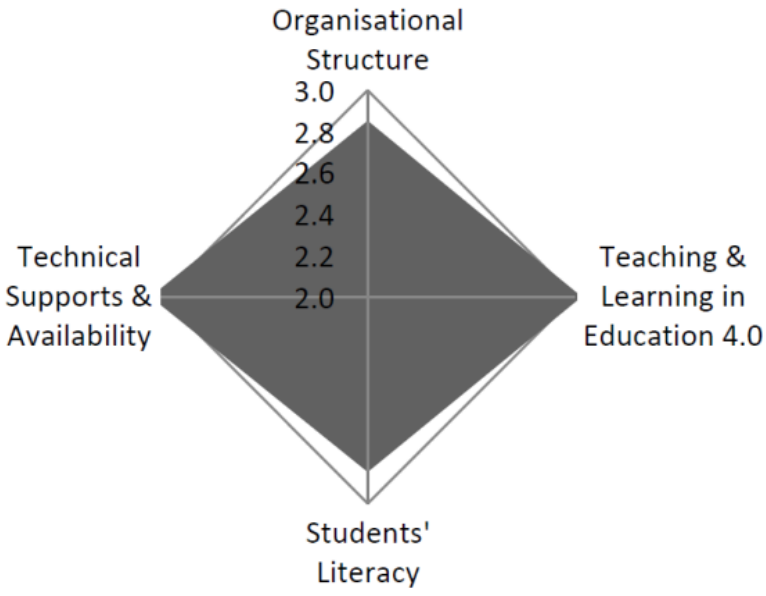

Figure 2. Radar chart of Readiness in Incorporating IR4.0 into Engineering Education in Four Dimensions

4. CONCLUSION

The preliminary results of the case study show that the initial model is applicable and able to predict the readiness of the mechanical engineering program in integrating the IR4.0 into engineering education with respect to the proposed dimensions and items. Further works include redefining the dimensions with further statistical analysis as well as developing a maturity index applicable to assessing engineering setup in incorporating IR4.0.

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