Transforming industrial engineering course content using an industry 4.0 MOOC based feedback approach

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Abstract

Teaching and learning in tertiary institution have experienced significant paradigm shift and new techniques are continually being explored for improving engineering course content delivery. The Fourth Industrial Revolution (FIR) is fast revolutionizing engineering course content delivery in industrial engineering with impact felt in all spheres. Having the right skills and strategies for online learning study assist in equipping the learners with necessary skills needed for the implementation of the FIR. Industrial engineering discipline deal with the design, planning, development, improvement, knowledge transfer, implementation, installation and evaluation of the performance of complex processes or integrated system of people technology and information. The objective of this paper is to discuss how the use of an industry 4.0 Massive Open Online Course (MOOC) feedback approach can transform industrial engineering course contents as applicable to industrial engineering course curriculum at the University of Johannesburg. The study was carried out through detailed evaluation of existing systems from which conclusions were drawn.

Keywords
Course Curriculum, Fourth Industrial Revolution, Industrial Engineering, Industry 4.0, MOOC.

1. INTRODUCTION

The Fourth Industrial Revolution (FIR) also known as Industry 4.0, has been a major contributor to advances witnessed in science and technology. FIR is the fourth major industrial era since the third industrial revolution of the 18th Century. In this era, there have been major inventions in mobile supercomputing, ubiquitous virtual simulations, neuro-technological solutions, self-driving transportation systems, genetic editing to brain enhancement and many others. The FIR is characterized by new technological innovations that have impact on biological, digital and physical worlds; economies and industries, and direct impact on academic disciplines. It is a phase characterized by intense dependence on machines for work being done on daily bases. It is machine driven, propelled by software's as seen in industrial equipment's and teaching media utilized in higher education institution such as University of Johannesburg, South Africa. Therefore, universities have a pivotal role to play in the integration of systems as well as implementation processes in the FIR era. Their ability lies in some few main dimensions: educating the new generation, developing new technologies and preparation for the current and future industrial development challenges. The aim of this paper is share the findings of the review which sought to identify curriculum improvement strategies and the influence of Massive Open Online Courses (MOOC) on the industrial engineering course curriculum through a carefully designed feedback system, which will cumulatively lead to transformation of industrial engineering curriculum development in South African universities.

The question to be asked in FIR pertaining industrial engineering programs is how best to determine the level of adequacy of the curricula in preparing industrial engineering graduates for current and future needs of the industry, where the graduates will be employed, since industrial systems are fast changing in-line with industry 4.0 demands.
Based on the research aim and objectives, the focus of the study is to determine how feedback system must be put into existing MOOC in order to track learner understanding, gaps, and opportunities for improvement of the industrial engineering course contents.

According to Xing, (2013), gamification can be applied for evaluating learner understanding of a subject matter using a fun filled feedback approach. Marwala, (2012), have shown that gaps within teaching programmes can be identified through electronic feedback systems, and MOOC is totally electronic, and the feedback analytics can be useful for identifying gaps and course contents that need improvement. This research requires application of data processing methods, and design software analytics. The updated knowledge of various subjects under teaching digital interests and massive open online courses had offering learning opportunities to teachers across the globe (Breslow and Pritchard, 2013). Furthermore, teachers received a lot of inputs on varied topics whereby the flexibility courses pave the way of collaborating with the online teaching community (Jordan, 2014). The scope of the research is limited to a few study areas which includes automation, advanced simulation, and virtual plant modelling. As a result, FIR on industrial engineering curricula will dramatically motivate and improve student's willingness to learn using new technological alternatives to enhance the learning process thereby bridge the gaps when new to the industry after obtaining a degree in industrial engineering.

2. LITERATURE REVIEW

What is 4th Industrial Revolution?

The backbone of Industry 4.0 lies in the use of internet and supporting technologies that are being used to incorporate, network equipment, humans in manufacturing systems, and other processes (Shead, 2013). These technologies include the use of artificial intelligence *(AI),* Internet of Things *(IOT)* and big data analysis (Eberhard et al,. 2017). These advances are predicted to be disruptive to our usual way of life, both social and at workplace (Kagermann et al,. 2013). Figure 1 shows the trend of the industrial revolution.

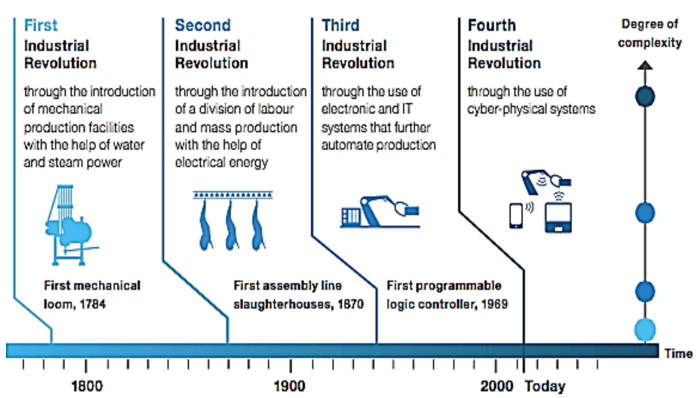

Figure 1: Trend and transformation of the industrial revolution

2.1 The Impact of fourth Industrial Revolution on Curriculum Development

The impact of 4th industrial revolution on the universities' curriculum is that, universities must come up with new course content that is flexible and adaptable to the demands of the FIR (Khaithan and McCalley, 2015). Lecturers are expected to find new approaches to teaching, delivering course materials, and the subsequent laboratory or practical work that must make students relevant for the future (Schutte, 2015). Universities are an important component in the development of any society or nation. Universities play their pivotal roles in educating and training the new generation, developing new technologies and preparing students for industry. Figure 2 shows the five ways workers and staffs can learn new technology while still working. Vocational training in-house, MOOC'S, graduate schools and self-directed learning are practical ways workers can learn new skills while at work as shown in figure 2.(Farrelly, 2018).

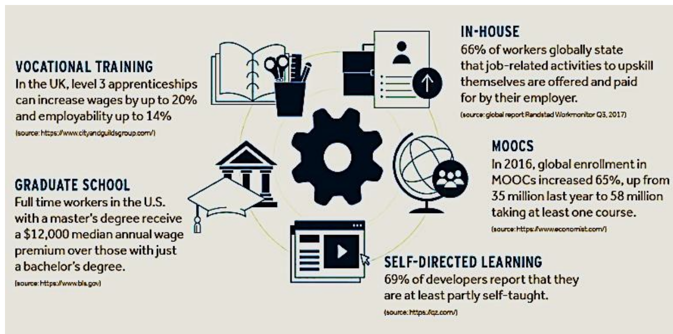

Figure 2: Five ways workers can learn new skills on the job

2.2 Massive Open Online Courses

Massive Open Online Courses *(MOOC's)* are courses made available over the intervention of internet without direct fees charged and is made available to many interested learners online (Hu et al,. 2014). They are mostly open access with unlimited participation via the world wide web. According to Christensen et al., (2013) the first *MOOCs* emerged from the Open Educational Resources *(OER)* movement, that response to a course called Connectivism and Connective Knowledge *(CCK*).
Universities are an important component in the development of any society or nation. Universities play their pivotal roles in educating and training the new generation, developing new technologies and preparing students for industry.

2.3 Industrial Engineering

Industrial engineering concept: Industrial engineering is a branch of engineering that deal with process optimization and Industrial Engineering curriculum development in engineering and build environmental and this discipline is paramount to the social- economic development of South Africa (Schutte, 2015).

2.4 Curriculum Development

Traditional Universities introduced a new curriculum program called Bachelor of Engineering Technology (BEngTech) of three years minimum programme across its technology-based curriculum programme. This curriculum was rolled out for the first time at the University of Johannesburg (UJ) in 2017. Traditional Universities across South Africa are currently phasing out the National Diploma Curriculum. The new BEngTech curriculum does not have the traditional one-year Work Integrated Learning *(WIL),* component that used to be part of the National Diploma. These new programmes have presented an opportunity to redesign Industrial Engineering curriculum so that it remains relevant to industry current needs and more so to the 4th Industrial Revolution (Khaitan, 2015).

3. METHODOLOGY

According to Khaitan and McCalley, (2015) and re-emphasised by Rodriguez, (2012), and based on the study of transforming industrial engineering course content using MOOC based feedback approach, it is worthwhile to mention that the above features presented in this research on MOOC have motivated the authors to consider the methods discussed herein in order to achieve the study aim and objectives. The method adopted focused on how industrial operations and industry process development should be accommodated in industrial engineering programme using MOOC. Opinions that led to the study questions include the following:

- Why implement Industrial Engineering open online Course (MOOC) in higher institution?
- How do MOOC platforms look and how can they be improved upon?
- Who teaches a MOOC and how are the course content developed?
- What are the needed essentials to start a MOOC? (Docq and Ella, 2015).
- How will questions and feedback be analyzed from data science and analytics perspective? (Hu et al,.2017)
- How will data be communicated in a dynamic form on the user interface for quick and easy understanding of the subject matter?
- How is Industry 4.0 currently being approached in terms of teaching and learning in traditional higher institutions? (Van Schalkwyk, 2013)
- How Industry 4.0 principles are is currently being included in some of the production and manufacturing systems design modules? (Amado-Salvatierra et al,.2016)

Figure 3 below summarizes the questions indicated above and further shows the definition of MOOC. The method to be adopted is a function of answers to the questions presented in figure 3.

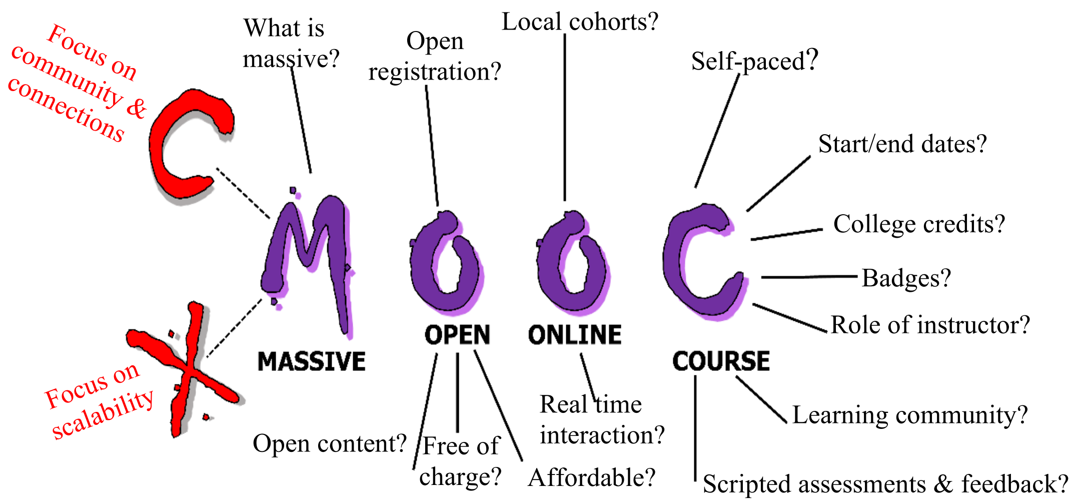

Figure 3: Questions to be asked based on the definition of MOOC

To conduct this study, the teaching methods utilized in classroom by industrial engineering lecturers in a traditional higher institution (University of Johannesburg), and the best approach to developing an online programme was evaluated. A popular industrial engineering course module was selected which is manufacturing systems design. Programmable Logic Control (PLC) teaching approach for a Siemens based PLC involving Comfort Soft Logo software for simulation of industrial equipment in a virtual plant was carried out and lessons were also delivered using the physical equipment in the laboratory. Comparison was made by considering the learning outcomes using the physical equipment as against the simulated equipment which had many more in-build options beyond the physical peripherals. Both options had obvious advantages and disadvantages. The learning process without a feedback mechanism had some obvious inadequacies. The same method was applied to fluid sim for simulating hydraulic systems and Simio, for production process planning and scheduling. Since the emphasis of the study was on feedback system, the outcomes were evaluated against existing MOOC in order to reach a common ground, and answer some of the study questions.

4. RESULTS AND ANALYSIS

In this sense, learning with MOOC Industrial Engineering curriculum development through the 4th industrial revolution was encouraged to understand the needs of a diverse population of students made to create tangible and accessible content, increase alternative laboratory practical technique teaching methods and evaluate different strategies for evaluation (Kagermann et al,. 2013) Hence, from the daily feedbacks received through quizzes, online assessments, collaborative group works, and module blog sessions over a full session, the best approach of online learning through 4th industrial revolution for industrial engineering module was identified. The seven processes that were explored on accessibility features in the phases of life cycle for fourth industrial revolution in industrial engineering in this study are the following (Amado-Salvatierra et al., 2016)

i. Conception and design
ii. needs analysis
iii. Framework analysis
iv. Development and production (Sperotto, 2015)
v. Learning process
vi. Programming implementation
vii. Evaluation and optimization

In this study, one of many examples of quantitative characterization of programming implementation, evaluation and optimization is presented in figure 4. To engage students, an industrial machine with conveyor belt system on a turntable roll line was simulated to show how Industrial Engineering process improvement can be achieved. Logo Soft software, a Siemens based Programmable Logic Controller (PLC) programming software for programming industry processes as shown in Figure 4 was utilized amongst many other similar applications in a typical classroom setting where each student is assigned to a computer system.

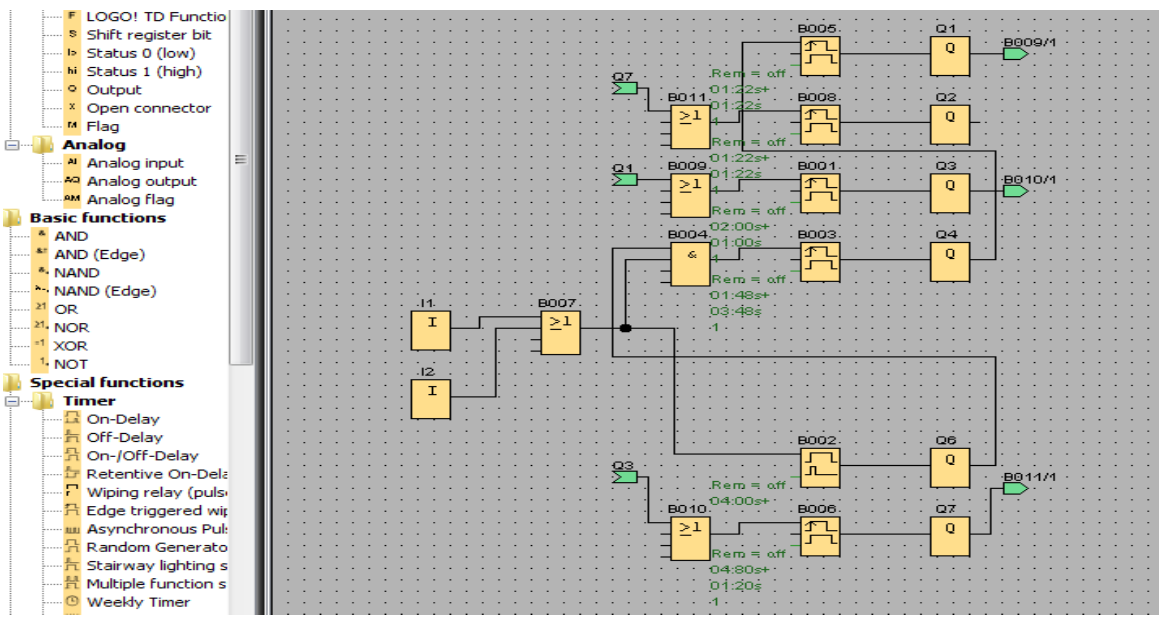

Figure 4: A typical example of programming in class: Conveyor belt with a turntable roll line machine

Table 1: Rubric to evaluate comprehension

Inputs / Outputs (I/O's)	Correct number of I/O	40%
Special functions	Correct use of special functions such as AND, NAND, OR, etc.	12.5%
Timers	Correct use of timers, ON delay, wiring relays, etc.	12.5%
Miscellaneous	Program retain properly, Latching relays, Retentive relays	20%
Program	Proper program simulation of the design	15%

Students are tested based on these five (5) evaluation criteria and based on success rate, they are allowed a second chance with results showing significant improvement after the first attempt.

The pros and cons of MOOCs are summarised in Figure 5 as shown:

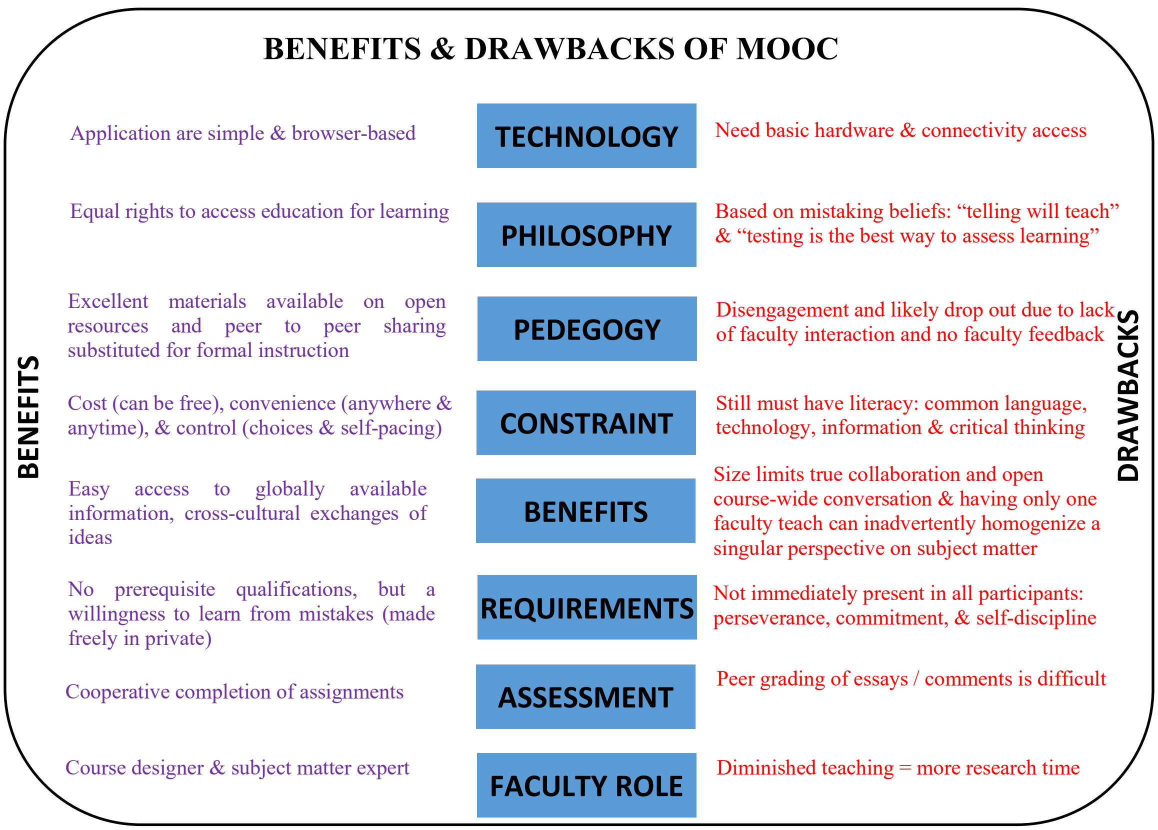

Fig 5: Advantages and disadvantages of the massive open online course (Chiam, 2016).

5. CONCLUSION

In this study, issues surrounding implementation and improvement of Industrial Engineering Curriculum content development using MOOC which is a fourth Industrial revolution approach has been reviewed. The findings of the study show the growing recognition given to the subject in many countries as well as its significant role in industry development. The Industrial Engineering Departments at the University of Johannesburg introduced new concepts and techniques suitable for maintaining and enhancing curriculum development, by utilizing an integrated online system provided by the university called ulink, an online blackboard platform. The platform is embedded with collaborative features, quizzes, online assignments, self-evaluation and re-evaluation for continuous improvement amongst many other features. Adoption of similar systems will generate feedback which lecturers can analyse and identify areas where students are struggling. This MOOC platforms as seen is just one of the features available in U-link which was found to be effective in this study.

Other findings were:

- The large size of the sample and the time period (session long analysis) improved the reliability of the findings. As such, random data analysis was effective.
- Further online studies can complement this study by utilizing more data from none students of the university (public participants) and addressing the limitations.

The approach and results of this study can be a starting point for the improvement of gaps in curriculum of industrial Engineering programs.

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