STRUCTURED ABSTRACT

UK & Ireland Engineering Education Research Network Symposium 2017: Time for Change! Challenging the Status Quo in Engineering Education

Agile engineering education for present and future

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SUMMARY

Agile engineering education (AEE) in this context is characterised by **mass customisation** through designing learning modules and learning pathways according to individual learner's needs and targets and **rapid inclusion of new contents** to synchronise engineering education with the evolving technological and societal environment. This paper proposes the strategy of building an AEE ecosystem and sub-ecosystems for resolving a range of fundamental challenges facing engineering education both at present and into the future.

BACKGROUND

The range of challenges facing engineering education both at present and into the future can be divided broadly into two categories:

Category 1: Challenges to current engineering education in HE institutions

(a) Diverse characteristics of students *vs* uniform requirements of graduates

(b) Rapid and diverse development of science and technology in real world *vs* limited and delayed coverage by engineering courses

Category 2: Challenges to engineering education for the society at large

(c) Increasing demand on life-long learning by technically trained people due to the fast development in science and technology

(d) The inherent 'engineering skills gap' between the provisions of engineering courses in HE institutions and the diverse individual requirements of industrial companies

(e) The need to inform, guide and support young people from an early age to engage with engineering activities and education to increase the supply to engineering profession
(f) The wide-ranging learning requirements of individuals in pursuing their own dreams

Most of these challenges are generic and will continue into the future, therefore some fundamentally different approaches have to be explored in order to find an effective and sustainable solution.

AIM AND OBJECTIVES

This paper proposes building an ecosystem and sub-ecosystems of agile engineering education (AEE) and demonstrates that the CIVA-type learning packages are strong candidates of the required learning modules of the AEE ecosystem.

THE PROPOSED AEE ECOSYSTEM

The proposed AEE ecosystem is composed of a collection of learning modules that can be selected and linked together to form learning pathways to achieve the mobility of engineering education for individual learners and to support the knowledge transfer for science and engineering within society. *Mass customization* is realized by designing learning pathways according to the specifications of the starting knowledge base and the target capability of the individual learner. *Rapid inclusion of new contents* is achieved by adding new learning modules to the collection. The capability and the performance of the AEE ecosystem depend on the quality of the learning modules and the ability of generating optimized learning pathways. The quality of the learning modules should be measured by a set of criteria including its value-adding capacity and its effectiveness and efficiency to achieve its full capability. The ability of generating optimized pathways relates to the availability of the number and range of learning modules as well as their relations. The fast developing Artificial Intelligence (AI) is expected to become a major technology to power the generation of learning pathways.

As shown in the next section, since the CIVA-type learning package generates a problem-solving focused structured learning process and, in addition, professional attributes and critical thinking skills are developed through the V&V process, it is highly effective and efficient in adding value to the learning process. Therefore the CIVA-type learning packages can be considered to be strong candidates of learning modules for the AEE ecosystem.

THE CIVA SYSTEM FOR ENGINEERING EDUCATION

Taking an evidence-based approach as well as considering the changing requirements for graduates and the increasing diversity of the students, the **CIVA** (**C**oursework-driven teaching & learning process, **I**ntegrated teaching approach, **V**erification & **V**alidation guided quality learning and professional development, and **A**ctive support mechanism) system was developed to achieve a high quality engineering education outcome that was characterised by high academic standard and quality, high inclusiveness and high employability [1].

The **CIVA** system represents a new way to organise the teaching and learning process and can be demonstrated to be an innovative implementation of the pedagogical principles that are recommended widely in HE organisations [5]. Essentially, the CIVA approach has put an emphasis on addressing the following four aspects that are necessary for establishing an effective and efficient teaching and learning process

(1) motivation of the learner
(2) desirable value-adding contents
(3) built-in mechanism of self-assessment and further self-improvement
(4) customised learning support

The CIVA system has been shown to be effective in

- Motivating, guiding, supporting and training students in their learning process
- Providing effective and efficient learner experience of 'learning through applying'
- Enhancing student employability through the discipline-representative problem-solving type of coursework that integrates the application of multiple key skills and provides a valuable experience similar to that found in professional engineering jobs
- Improving inclusiveness mainly due to the built-in flexibility of the coursework in how learners self-allocate time and resources and the active support mechanism

Several examples can be found in [2-4] that illustrate how the CIVA system has been implemented in teaching several engineering science subjects on a Mechanical Engineering course. Furthermore, some evaluation of the CIVA approach based on student feedback and some discussions on the requirements for adopting this approach are presented in these papers.

SOLUTION TO CHALLENGES

The proposed AEE ecosystem, in principle, can provide solutions to all the challenges listed above. However, taking into account the particular characteristics and requirements associated with Category 1, it is considered separately.

Solution to Category 1: AEE sub-ecosystem with pre-defined learning targets

For the existing engineering courses in HE institutions,

(a) Diverse background of the entrants is largely the result of widening participation and internationalisation, and both are highly desirable for the advancement of the human society.
(b) How the engineering course provision can keep up with developments in the real world and meet the requirements of industry and society in a timely manner is an inherent problem but the faster changing world in recent years has made this difficulty more acute than ever before.

It is predicted that these trends will continue into the future. To resolve the problems, the AEE sub-ecosystem approach may provide a solution.

To be consistent with the existing course structure, the learning pathway should be designed within each unit and the learning target at the end of the pathway should be set as the learning outcomes of that unit. The *mass customisation* feature essentially aims to

achieve inclusiveness so a converging preparatory study at the starting point for reducing diversity and an inclusive T&L process are required. The *rapid inclusion of new contents* feature can be realised by adopting the CIVA approach or similar and it provides the flexibility for the actual course contents to be updated.

Solution to Category 2: AEE ecosystem with full customization

The AEE ecosystem for the society at large will have a more profound significance to how engineering education may exist in future. Building the AEE ecosystem requires the application of the concept of sharing economy to engineering education. Many stakeholders will need to contribute to the AEE ecosystem and benefit from it for its creation and sustainability, as indicated in the summary below. However, it is expected that engineering academics will always play the central role in connecting with other stakeholders and in creating learning modules/pathways of the AEE ecosystem. This will establish the status of engineering academics as a critical force to the prosperity of the future society as their mission will extend from serving their 'enrolled customers' to the creation and maintenance of the 'learning society' for mankind. Engagement in the 'learning society' by a large proportion of the population is of critical importance for the survival and prosperity of the human race in the foreseeable future when people can be looked after in 'comfort and convenience' by the AI powered living environment.

Summary of the main benefits and significance of the proposed AEE ecosystem:

(a) The AEE ecosystem will help resolve all issues listed above because the **mass customisation** works on the individual basis and can take place at both the starting point and the target point of the learning pathway.
(b) The AEE ecosystem will **connect** the engineering education in academic institutions, the industrial companies and the potential engineers in a constructive and progressive way. This effective communication will create a multi-win scenario for all stakeholders.
(c) The AEE ecosystem will provide **customised** learning provision based on the individual starting point and desired learning outcome, so it will be more effective and efficient for the learner and therefore more attractive as well as more practical for people to use on their journey of pursuing their own dreams.
(d) The AEE ecosystem will **motivate the engineering academics** to engage with the latest scientific and technological developments as the learning modules that they create will contribute to building the 'learning society' and can generate a wide and long lasting impact. Furthermore, such engagement will increase their capability and opportunities to collaborate with industrial companies, which is beneficial to both industry and engineering education.
(e) The AEE ecosystem will **motivate the industrial companies** to work with academic institutions as their contributions to the learning modules will help recruit better qualified engineers for their industry.
(f) The AEE ecosystem will facilitate the **funding** for implementing the government Industrial Strategy to be spent more effectively as the Learning Centre as part of the AEE ecosystem needs to be equipped with high standard and up-to-date software/hardware facilities and personnel.

CONCLUSIONS & RECOMMENDATIONS

The proposed AEE ecosystem is an attempt to explore ideas for finding a solution for resolving the widely recognised deficiencies of the current engineering education and for building a 'fit-for-purpose' engineering education for future society.

Building the AEE ecosystem requires the application of the concept of sharing economy to engineering education and it will generate a multi-win scenario for all the stakeholders and the society as a whole. Engineering academics should play a central role in the creation and maintenance of the AEE ecosystem and their contributions to the 'learning society' for mankind will be recognised with a wide and long lasting effect.

The CIVA system presented is an innovative approach to engineering education. It has been shown to be effective in improving student engagement and be efficient in adding value, thus increasing value-for-money of the learning process. Therefore, the CIVA system should be able to contribute to the engineering education reform that many HE institutions around the world have been exploring.

Furthermore, the CIVA-type learning modules are recommended for the proposed AEE ecosystem. When a large number of such learning modules covering a wide range of topic areas have been created and the capability of generating optimal learning pathways has been developed, the ecosystem of AEE will be formed.

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