

# Co-creative engineering curriculum design – Case East Africa

Ville Taajamaa,  
Department of Future Technologies  
University of Turku  
Turku, Finland  
ville.taajamaa@utu.fi

Antero Järvi  
Department of Future Technologies  
University of Turku  
Turku, Finland

Samuli Laato  
Department of Future Technologies  
University of Turku  
Turku, Finland

Johannes Holvitie  
Department of Future Technologies  
University of Turku  
Turku, Finland

*Abstract—* This work-in-progress study reports the first findings from an engineering curriculum design process in an East African context. The design of new programs and teaching practices involves three universities with local faculty designing a new engineering curriculum with external experts involved in the design process. Innovation is something that in addition to societies and industries also the global academia is striving towards, and not only in research but more and more so also in education [1]. The big question, however, is how to achieve this and how to make innovation happen inside the classroom when the faculty needs to push the boundaries of science while at the same time being transformative educators [2]. And all this in a global higher education environment, where well-established institutions are in the cross pressure of neoliberal worldview and the humboldtian ideal of the community of scholars [neoliberal]. On the other end innovation and creativity are argued to be products of co-creation and a non-controlled if not chaotic and emergent environment. Much different from tradition and critical thinking (devils advocate) driven scientific world or establishment that sees cultural change and societal pressure often as a threat to their independence. The empirical part for this study involved several co-creation workshops where students

and faculty participated and where co-creative learning methods were tested in a local environment. Although the processes ran parallel and were not coupled together both workshops gave insight on the preconditions of curriculum design and design of learning methods in the context in question. The Northern European university in question was responsible for organizing the workshops in collaboration with East African partners. The results show that there are several constraints for curriculum design and the adoption of new learning methods. The first results using the co-creation model proved, however, useful. The process of curriculum design and implementation will go on for the next two years until year 2020.

*Keywords—* curriculum design; activating teaching methods; East Africa

## I. INTRODUCTION

Curriculum design and implementation is a basic and continues practice for university faculty. In this work in progress (WIP) paper we study the co-creative design process of three East African engineering and or STEM based masters' programmes with the fields of either IT or Data Science embedded in to them. The aim is to share the first results from the curriculum design process based on a observation method close to ethnography. The results are communicated from a viewpoint of an external expert albeit the process itself is analysed from a viewpoint of the subject. This is mainly because of the phase of the overall project. Please see Results part for more information. The time line for the study is from a ten months period and the whole project with implementation and follow up lasting up to three years. The external experts in this project were all faculty members from Nordic universities.

### A. Capacity building projects in Tanzania

The Nordic University in question is currently involved with two conjoined capacity building projects in East Africa, in which education plays an important role in the projects. The main intended project level outcome is to catalyse local industry collaboration through the development of curricula and teaching methods towards more project based with open-ended real-life challenges. Main aim being to narrow the gap between western industry or business driven thinking, and on the other hand local rule based approach.

In practice, previous work-in-progress research has identified that when local stakeholders have capability to work with modern technologies, they discern and iterate on radical ideas, and they teach their peers [edström, graham].

The second intended outcome is to implement practical education development methods to the local context together with the local partners. These include expert training, facilitation of curriculum design and new teaching methods, and curricula review. In the expert training, mainly East African faculty visit the Nordic University for training periods. They acquaint themselves with the issues and contexts the locals are working with. Through out the multi-year endeavor, the participating HEIs (higher education institutes) encourage sharing of thoughts and experiences about matters related to teaching so as to facilitate discourse and development.

Finally, all these methods ensure that both parties have an exhaustive and shared understanding of working contexts at both ends.

### B. Theoretical background

The key pedagogical ideas we wanted to utilize in our design were the epistemology of constructivism [1] and theory of active learning [2]. The well acknowledged approach of constructivism implies that students build new knowledge on top of their prior knowledge, which in the context of an engineering curriculum is especially important, as the prior knowledge students have, upon which they start to formulate

new knowledge, might vary a lot between students. In order to engage students in the desired knowledge construction processes, whilst taking into account the variance in students prior knowledge, methods that boost motivation and learning outside class are required. Empowering students to learn outside class has been linked with positive learning outcomes compared to lecturing heavy teaching methods in the domain of science courses, in this case biology [3]. These positive learning outcomes are the undeniably linked to active learning [4].

Project based learning [5] as a form of active learning has been identified as an effective method of learning by doing, where students need to figure out problems and individually discover solutions without excessive guidance from teachers. Piaget's theory of cognitive development argues for learning through personal empirical experiences and it aligns well with constructivistic ideas where students build new knowledge on top of their prior knowledge [1, 6]. Project based learning additionally addresses the issue where students have different levels of knowledge, as each student finds their own problems to work on in order to contribute to the project outcome. Previous studies in the East-African context have also suggested the use of experimental learning techniques instead of traditional lectures as well as to involve students more in extra-curriculum activities [7].

Theories for education developed and tested in the western society might have cultural bias, meaning that implementing them straightforwardly in the East-African context would not be optimal, as discussed, for example, by Banks [8]. The high level epistemologies and theories identified in this section work as a knowledge base for our design, but must be applied cautiously whilst working in open dialogue with the students and teachers in our target country. Copying an established engineering curriculum from a western country is therefore not a viable option, and a new design, utilizing previous studies in other cultural contexts, is required.

### C. Success as an exception to the rule

University or even programme level change is not easy. This intuitively familiar thought for all educational developers is well supported by scientific research. Both Graham and Edström found this to be the case in their research of curriculum and teaching methods development (graham, edström).

Both emphasize the poor sustainability of change and suggest that there should be a new way of perceiving educational development.

Edström 2017 elaborates with two questions why organizational level change is difficult to achieve [2].

1) why do engineering curricula mainly consist of courses that reflect the organizational boundaries of the university?

2) why it is difficult to integrate learning outcomes related to professional practice? [2, p.48].

The first question reflects how difficult it is to sustain collaboration between disciplines. Even when there are both resources and management support the lack of personal level

connections and trust can hinder the survival of long-term collaboration.

The second question touches upon educators role both in terms of engineering profession and in academic profession. An engineering faculty has two roles. They are expected to further science through research typically using natural sciences and secondly to give teaching based on research yet also in a way that knowledge and skills needed in engineering profession are enhanced.

The challenge is that if we look deep enough this means you need to have two identities – the identity of an academic person and an engineer. Definitely doable yet challenging. The first follows a deductive path as the role an engineering educator profession has constructivism as the philosophical worldview. Often the previous prevails.

## II. METHODS

This research follows the Participatory Action Research method where the researcher can also be a participant in the researched phenomena [ref]. After the topic of research is identified and data is collected and analyzed, the researcher or the research team can do an intervention to the researched topic. This presents one PAR cycle. After this another cycle can be started. The amount of cycles is depended on the researched phenomenon and the set target.

The data for this WIP-paper came from feedback surveys collected from the faculty and student workshops, and from observations. Analysis method was a combination of basic statistical methods and a thematic analysis and discourse.

### A. Case description

The authors' (experts) involvement in the curriculum design and development work began in August 2017 when faculty members of the four East African universities were visiting the the Northern European university in question. In a planning workshop we discussed the motivation behind the new curricula, overall contents, current status and anticipated timeline of development of each targeted curriculum. For one of the targeted curriculums the experts had had an opportunity to discuss with the faculty earlier when the curricula design had just started. The remaining two were in late stages of development at the time of this the August workshop. Based on this we sketched a two-phase curriculum design project. The first phase was a more traditional curriculum review project aiming at benchmarking, scoping and improving the contents of the curricula during the design and ending in the submission of the curricula for acceptance. While curricula review is a rather formal method, it is crucial that the design of the curricula reflects the intent of both parties to train capable individuals. The idea is that if we are able to observe challenges, we can also distill solutions possibilities and use the provided infrastructures to come up with feasible implementations of pro-active and constructive degree structures and teaching methods.

The second phase was planned to start before and continue thorough the first implementation of the curricula. The focus of the second phase would be on new teaching methods to foster innovation and creativity in the classroom.

The intended working methods for phase one were written recommendations by the external experts based on detailed analysis of the curricula design documents, followed by workshops between experts and faculty members. The purpose of the workshops was initially mainly to prepare for the phase two of the project, but also to deepen the mutual understanding of the constraints and proposed modifications to the curricula. However, despite the considerable previous experience on ICT and engineering curricula development, extensive course development and teaching experience, also in Asian universities and even some previous collaboration with East African universities, it very soon became evident that the targeted themes of innovation, creativity and related transferable skills left the external experts with very little ground to justify our recommendations considering the local context. The main uncertainty was the readiness of the students and the faculty to engage in learning and teaching methods that require stepping out of the comfort zone of lecture heavy teaching methods. Earlier the same year external experts had organized and run an innovation workshop with masters students from IT and Geography majors in East Africa, on the topic of smart city solutions in a developing country urban context [12]. This led to the idea of using similar workshops as a tool in the curricula development process to test the applicability of these teaching methods in the targeted environment, with the targeted students. It was not seen at this point that there was a big mismatch on how the East African faculty members and external experts understood these methods. The workshops turned out to be valuable also in unifying the mutual understanding on the main goal actually was and how the implementation of the whole curricula development program could be achieved.

The timeline is as depicted in table1

May 2017	Innovation workshop with students and faculty from universities A and B.
May 2017	Discussion with the faculty of university C at the beginning of a new curricula design project.
August 2017	East African faculty members from universities A, B, C and D visiting the North European university. Workshop for planning the co-ordinated curricula review process.
Aug-Nov 2017	First round of reviews and written comments on the contents of curricula design documents for universities A, B and C.
November 2017	Two one day innovation workshops with students and faculty from universities A and B.

May 2017	Innovation workshop with students and faculty from universities A and B.
November 2017	Discussions with faculty members from universities A, B, C and D, one university at a time.
Dec 2017 - Mar 2018	Second round of reviews and written comments on the contents of curricula design documents for universities A, B and C.
March 2018	A two day innovation workshop with faculty members, students and external subject matter experts in university D
March 2018	Discussions with faculty members from universities A, B and C, one university at a time.

### III. RESULTS

This section will deal with the themes and phenomena that have risen from the preliminary observations, discussions, workshops and from the curricula reviews with the local faculty and faculty leadership. The themes are listed below

List of themes and phenomena that arose from the curricula development work:

1. The timing of both the design and process phase of the curriculum development influences the intervention possibilities considerably. If the curriculum development has reached the needed form for example for the government auditing the process owner is interested to get forward to the next phase instead of for example focusing on the development of learning methods. The curriculum or program description should be so that both the first program and course level descriptions exists but there is still a need for the to go through it together.
2. Workshops with students helped considerably to better understand what implementation challenges the curricula will have in practice. It brought contextual and situated understanding of both the opportunities and local boundaries. Project-based learning for example can in practice mean very different things. It can be that a open-ended and complex challenge from the industry or other stakeholder, which requires an interdisciplinary team or it can be just a

simulated exercise with a case from a text book. All in all the two processes: student workshops and the actual curriculum development combined in a cyclic process provided much needed understanding of the local context.

3. Curriculum design workshop participants had varying experience in using these methods both in terms of extent and way of implementation. In the initial discussions in August 2017 the approach to learning methods was theory-oriented and the scope was the whole curriculum. It was really difficult to discuss about the design and envision the possibilities in any tangible terms. However, after a few shared experiences through the co-creative learning workshops this changed. It became possible to identify individual courses where new learning methods would be implemented, extend and modify the concrete learning outcomes accordingly and even work on difficult issues such as assessment of courses that apply co-creative learning methods. As a summary, the co-creation workshops created a common ground for both parties and aligned the terminology on learning methods in the curriculum design process.

### IV. DISCUSSION

This work-in-progress study aimed to report the preliminary findings from an engineering curriculum design process in an East African context in collaboration with a Nordic university. The design of new programs and teaching practices involves three universities with local faculty designing a new engineering curriculum with external experts involved in the design process.

The empirical part for this study phase involved several co-creation workshops where students and faculty participated and where co-creative learning methods were tested in a local environment. Although the processes ran parallel and were not coupled together both workshops gave insight on the preconditions of curriculum design and design of learning methods in the context in question. The Northern European university in question was responsible for organizing the workshops in collaboration with East African partners. The first results showed that there are several constraints for curriculum design and the adoption of new learning methods mainly based on the timing of the program design and the understanding of local needs. The first results using the co-creation model proved, however, useful. The process of curriculum design and implementation will go on for the next two years until year 2020. The next focus will be in the actual implementation of the programs.

## VI. REFERENCES

- [1] Taajamaa, V., Majanoja, A-M., Bagiati, K., Guo, X., Leppänen, V., (2017), "University Education as a Pathway to Innovation Perspective on Building Students Innovation Capabilities in Sino- European Education Set-up", Journal of EHEA,
- [2] Edström, K., (2017), "Exploring the dual nature of engineering education – opportunities and challenges in integrating the academic and professional aspects in the curriculum" Dissertation, KTH, Sweden, 2017
- [3] Wubben, Z.C., Ford, D.R., (2016), "[News media and the neoliberal privatization of education](#)", Information Age Publishing
- [4] Graham, R., The Royal Academy of Engineering, (2012) "Achieving excellence in engineering education: the ingredients of successful change", The Royal Academy of Engineering,
- [5] Von Glasersfeld, E. (2013). *Radical constructivism*. Routledge.
- [6] Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, 111(23), 8410-8415.
- [7] Knight, J. K., & Wood, W. B. (2005). Teaching more by lecturing less. *Cell biology education*, 4(4), 298-310.
- [8] Jensen, J. L., Kummer, T. A., & Godoy, P. D. D. M. (2015). Improvements from a flipped classroom may simply be the fruits of active learning. *CBE—Life Sciences Education*, 14(1), ar5.
- [9] Hadim, H. A., & Esche, S. K. (2002). Enhancing the engineering curriculum through project-based learning. In *Frontiers in education, 2002. FIE 2002. 32nd Annual* (Vol. 2, pp. F3F-F3F). IEEE.
- [10] Piaget, J. (1984). *Piaget's Theory of Cognitive and Affective Development*, Routledge
- [11] Banks, J. A. (1988). *Multicultural education: Theory and practice*.
- [12] Creswell, J. W. (2009) "Research Design - Qualitative, Quantitative, and Mixed Methods Approach", Sage Publications Inc. Third Edition,
- [13] Holvitie, J., Vasankari, T., Järvi, A., Eilola, S., Hyrynsalmi, S., Käyhkö, N. & Makandi, H. (2017) "Platform-Driven Ecosystem Prefacing for Emerging Markets in Developing Countries". Proceedings of the 9th International Workshop on Software Ecosystems. (CEUR workshop proceedings; vol. 2053), 2017