HED 2.0 - HOW MUCH CHANGE DOES ENGINEERING EDUCATION REALLY NEED?

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ABSTRACT

The number of young people enrolling in scientific and engineering fields in higher education [HE] is decreasing for two major causes: 1) students choosing other fields of higher education which appear to offer better chances to influence the development of the society, social visibility and financial prosperity and 2) potential students neglecting HE at all and pursuing faster tracks of education enabling them to participate in economy and social life much faster and with clear, reachable role. We no longer know what future engineers will be doing and what knowledge and skills they will need. Fundamental knowledge in any profession has grown 1000 times since 1900 and most engineers will be working multidisciplinary needing several professions. This paper tries to understand and leverage from WEB 2.0 which is not a new technology but rather a new way in which existing technology (Internet, XML/HTTP, streaming, virtual reality, …) is used. Before it, users were passive consumers of content provided mostly by organizations within the framework of their activities they thought are important for their customers, clients, citizens, users. Web 2.0 creates a number of virtual constructs that activate users making them providers of the content and putting them in intensive, continuous interaction. HED 2.0 stands for "Higher Education Completely Revisited" and is a mental exercise trying to understand how could HE be organized so that students could become active creators of their learning process, using its components for what they believe is important to them and thus taking major responsibility in their own education. Engineering profession (and education) has to be(come) fun, promising, challenging and attractive to both students and high school children. It can be so only if they are presented with a range of exciting, meaningful and challenging projects they can immediately participate in: human colony on Mars, artificial intelligence, world peace, secure home, secure transportation, machine teaching etc. Each position within a project should define its "required knowledge base" that would become a student's curricula. Specified granules of engineering knowledge and skills in such a curriculum would be acquired by students at

their own pace and method using recorded lectures, video documentaries, virtual laboratories and mini projects. Students would verify their progress by results of projects and through globally standardized, computerized exams. Teachers would become mentors, advisers and designers of courseware, exams and projects. Thus borders between HE and life long learning would dissolve in content and methods.

Keywords: WEB2.0, project based learning, e-learning, self-examination, student's responsibility for learning outcome

1 INTRODUCTION

This paper is based on the wide recognized fact that the number of young people enrolling in scientific and engineering fields in higher education (HE) is decreasing [1][2][3][4]. It is also based on the conclusions of some surveys that there are two major causes. For one, potential students choose other fields of higher education because they appear to them to offer them better chances to influence the development of the society, to gain social visibility and to ensure better financial prosperity[5]. The second cause is that potential students neglect higher education at all and pursue faster tracks of education which would get them in position to participate in economy and social life much faster and with clear, achievable role. An example of the latter is particularly recognizable in the field of computer engineering where education is provided by globally renowned systems (e.g. Microsoft, CISCO) and their sought after certificates.

This paper is not trying to find an answer to the question: "What a (single) school or university should do in order to survive" nor "What current system of HE should do to survive. It is rather trying to figure out what might HE system look like that would be appropriate and optimal for the emerging world.

From educational point of view, especially engineering education, the world is global. The major part of curricula for a particular profession is pretty much the same, regardless of geography, political orientation or wealth level.

2 CURRENT EDUCATIONAL SYSTEM

The current education system was designed when senior scientists believed they knew what future engineers will be doing after graduation, what knowledge and skills they will need to do that. So, they believed they knew what and how students need to be taught. Therefore, they designed the educational system and ran it. They designed curricula and certificates to prove student's abilities. They also run verification processes, exams.

Student's role is to follow the path in scope, depth and time as closely as possible. And then s/he would be awarded a certificate.

2.1 THE FUTURE

The future is much less clear. Some would say that it is very unclear. We increasingly tend to agree that no one can for sure say what exactly will future engineers do. Accordingly, it is getting hard to know what knowledge and skill they will need.
Being so, the solution is sought in focusing student's education on "foundations" of a profession. The rest of required knowledge is assumed to be acquired by life long learning.

2.2 THE PROBLEM

The "foundation knowledge" has been enlarged hundreds, perhaps thousand times since the existing model of HE has been put in place. Since the duration and format of HE has not changed, much thought has been given to and many battles fought over what belongs to foundation knowledge today[6].
Further, percentage of engineers working in their "pure" profession is small, while majority is working interdisciplinary and multidisciplinary[7]. This means that they should get foundation knowledge from two or several professions. However, it is difficult, if not impossible to tell which foundations before knowing what would be their future job. Even more, this changes as an engineer moves from one project to another[8][7].

2.3 THE OTHER PROBLEM

Students could (maybe should) be considered to be customers for HE content and process. They have interest in what they are being taught and how are they being taught. These customers are lowering their demand for HE for three mayor reasons. First, they it is not clear to them what will they be working when they graduate: the types of jobs, projects, activities, endeavours. Second, what they see is not appealing enough in the sense of being able to make an impact in the future, to have social influence and to be financially secure and well off. Finally, they find the existing HE process to be boring, out of their influence and not being adjusted to their needs, abilities, existing knowledge nor their own rhythm and tempo.

2.4 YET ANOTHER PROBLEM

The industry could be considered to be the "customer" for HE "end product": the engineers[10]. They would like those engineers to be able to "produce" from the moment they graduate[11]. When new knowledge need arises, employers

would like their workers to be able and in position to acquire new knowledge and skills fast and promptly, with appropriate quality[11].
HE system does not meet those needs. Of course, it would be practically impossible to produce engineers for every single production type in the world, but in many countries HE is not doing the best job in meeting economy's demand for life long learning.
Finally, newly graduated engineers have to face mayor difference in learning process between the HE system they are used to and the life long learning[13].

2.5 LIFE LONG LEARNING

Whenever something changes in production process, we need to learn. Regardless whether it is a new product, component, process, organization, market or something else. Employees need to recognize what is missing in their competence. Sometimes those are organizational skills they can acquire within their organization, or social or personal skills for which they can use various open/public trainings to master but often they lack professional knowledge and skills. Some can be acquired merely by assimilating information. Others would require much deeper and longer study of the background, causes and consequences, rules and methods, tools and concepts. Some will require exercises and practical experience. Another would need mini or pilot projects in order to gain required competence.
Life long learning has always been around. Recently it got much attention of of educational community, media and corporate planners because the rate of changes in our work and life has significantly increased. As the result, competences that once sufficed for the whole career, now last less than a decade. Competence acquired for new project will not be sufficient for the next one: it will need to be amended. Thus, the term "continuous education" was coined since it seems as if education never stops[13].
When a professional (an engineer) becomes aware of his/her need for (professional) education s/he has very particular use in mind, most of the time. They need just that specific competence: knowledge, skills, experience. They do not have resources to broaden that educational effort much beyond their immediate need. They also need that education right now and fast.
On the other hand, if required competence is from a professional field that is completely new to them, they are in the position of any HE student: they are a complete novice. For example if and electronics or computer engineer joins a project in genetics they need to acquire some fundamental knowledge in biology and genetics. They lack competences to chose and define their educational path on their own. They need guidance, and a profession's foundation knowledge. But they still need it focused with their need in view, prompt and fast.

3 WEB 2.0

WEB 2.0 is a denotation not of a new technology but rather of a way in which the existing technology is used. It is a "tag" for virtual constructs that, using Internet, HTML, HTTP, streaming, virtual reality and other decade old technologies, activates users making them providers of the content and putting them in intensive, continuous interaction.

Before WEB 2.0, users were passive in sense that they searched for and consumed content somebody else provided. Most of the content was provided by organizations within the framework of their activities: activities they thought (but couldn't know for sure) are important for their customers, clients, citizens, users. In essence, before Web 2.0 the flow of information was unidirectional: from those who had information to those who needed it. The "owners of information" were considered to be either the sources of information (industry, explorers, thinkers) or recognized presentation and/or distribution entities (news media, educational institutions, publishers, trade organizations). Influence of users on the content and the form of information published was minor. There was not much difference from old-fashioned "physical" information world.

In the Web 2.0 world all "old" information sources continue to exist, but majority of information exchange is happening among users. Users of information became sources of information, as well. They process, repackage, formulate and design new information and they publish it in numerous ways: blogs, social networks, RSS feeds, postings (text, photo, video, …) and mails.

In search for information, users first go to their peers and social networks, before turning to "primary" sources of information.

From passive consumers, users became active creators. They are involved, passionate, demanding in their pursuit for information and they are in an intense social interaction.

4 HED 2.0

Drawing parallel with Web 2.0, in modern HE users (students and industry) should become active in defining, formulating and consuming education.

So, it seems that ideal HE would have the following properties. Students would, from their first to very last day, have a clear vision where are they heading, what would be their competence and how to achieve it. They would have the ability to check by themselves how close to that goal have they come, all the time.

HED 2.0 stands for "Higher Education 2.0" of "Higher Education Completely Revisited" is a mental exercise in trying to understand what could be directions of organizing higher education in a way in which students could become active creators of the process as well as using its components for what they believe is important to them.

The process would be adjusted to their abilities, priorities and resources[16]. The process would be meaningful, enjoyable and under student's control. There would be no significant difference in the educational process, in learning and teaching, between HE and life long learning.

4.1 PROJECTS, NOT TITLES

Since no one can tell for sure what any future engineer will be really doing after graduation, student's opinion, even guess, is as good as anybody else's, including experienced university professor's. Since, it is about student's life and career it seems to have much more sense to entrust the decision on the course of professional development to the student himself.

Instead of creating new professional titles and designing curricula for them, perhaps the course of one's education could be defined through projects. Universities could offer a variety of challenging, real-life, practical projects for students to work on[14] like: human colony on Mars, artificial intelligence, world peace, secure home, secure transportation, machine teaching etc. Every position in a project team would have defined prerequisites: knowledge and skills a student needs in order to successfully perform that role in the project team. Those prerequisites, granules of knowledge, would be similar to current subjects.

In such a way, a student would model her/his own career through projects s/he would participate in. Employees, too, would have much clearer view on student's competences from the list of her/his projects, positions and accomplishments.

4.2 EXAMS

What about exams? Well, only the project outcomes and individual contributions would be judged upon, ranked and marked by mentors and project leaders, including non-technical aspects so important in real workplace: ability and willingness to learn, teach, mediate, unite, lead, reason, think, … The results of learning effort to acquire a specific granule of knowledge, to fulfil the prerequisite would actually only matter to a student. S/he is the most interested person in having the required competence In order to successfully complete the project assignment. They should have the means to check their knowledge and skills in any specific area by themselves, anytime and as many times during the learning process as they feel the need to.

4.3 VERTICAL LINK

Important feature of such a system would be its "vertical extendibility" in both directions: life long learning and high-school education.

Professionals preparing for new projects and professions, realizing their need for a specific knowledge could participate in those HE projects as well, and thus acquire required knowledge and skills.
Junior or "scout" positions could be formed in projects, designed for motivated high school pupils who could early on experience future professional area and gain insight into what would it be like to enrol in a specific HE as well as what would it be like to pursue such a professional career[15].

4.4 CAN IT BE ACHIEVED?

It is obvious that current organization of HE could not create and realize such a system. Proposed system requires that acquisition of granules of knowledge be heavily based on self-learning. However, it does not mean letting students to cope on their own. On the contrary, it means fully supporting them from technological and human side.
On one side, students should be provided with ample educational resources: video recordings of lectures, video documentaries, digitized texts, digital programmed textbooks, virtual and distance laboratories, simulations, visualizations and finally, computer based exams. Whatever they might need in the course of learning should be there, available 24/7 at their fingertips.
On the other side, in those moments when student would need human assistance, it should be readily available: to counsel, to teach, to advise, to guide, to mentor to be the sounding board.

4.5 WHAT WOULD BE THE NEW ROLE OF UNIVERSITY PROFESSORS?

"To become wells of knowledge, no more fountains" – a poet could say. Or in other words: anything that could be entrusted to computers to do, should be. Thus freeing teachers to do those things that only humans can do.
To study students and their learning process in order to provide needed new and revised materials, to improve the process, to act as a balance in the process, corrective function and guide line. Teachers would focus on their role as mentors, advisors, project leaders and masters of a discipline. In an attempt to answer the question: "How to become a master?" an ancient saying says:

Look to the master,
Follow the master,
Walk with the master,
See through the master,
Become the master.

Professors should be those masters for students to look to, follow, walk with and see through.

4.6 CONCLUSION

In order to attract young people to engineering a coordinated effort of HE and industry is required. Industry should provide challenging projects and material resources for their execution [17][18]. Universities should design and run the process.

Universities should provide resources for self learning of knowledge granules and a stimulating environment for students to work on projects.

This means that professor's roles should change form current predominant "broadcasting" of knowledge to the role of designers and authors as well as mentors and advisors. The key issue in judging a universities' ability to accomplish such a major change, is the motivation of their faculty to undertake any serious change and practical experience of faculty enabling them to be masters of the discipline, not just scholars.

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