VERTICAL INNOVATIONS NECESSARY FOR INCREASING THE ACCESSIBILITY OF ICT ACADEMIC PROGRAMMES

ВЕРТИКАЛНА ИНОВАЦИЯ ЗА ОТВАРЯНЕ НА УНИВЕРСИТЕТСКИТЕ ПРОГРАМИ ПО ИКТ

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Abstract: *The specifics of the ICT labour market require continuous and rapid qualification and retraining of staff. At the same time, the existing conventional educational structure does not allow the rapid adaptive retraining of specialists as the majority of university programmes are based on a fixed set of foundation courses and a modular education system. This paper describes a new concept for academic curriculum structure that aims at providing open access to the curriculum excluding the historical relationships in forming the foundation of knowledge, and opens the market of educational services to other providers, such as colleges, private academies and practical hands on experience. The presented model encourages competition and does not allow dividing the operators of educational services into new entrants or players in a dominant position, thus the concepts found in real terms realisation of new undergraduate program in Network Engineering at New Bulgarian University.*

Keywords: INNOVATION IN ICT EDUCATION

Introduction

The introduction of online technology in university training has created new opportunities for teaching innovation. Online technologies have already changed the educational services market worldwide. The disruptive effect of online innovation has made way for suppliers of new educational services on the market and has changed the dominance of state and private schools and universities [1]. This tendency has been observed worldwide (USA, Europe, India, etc.). The largest universities are actively developing online training platforms, but most of them are using very simple models, such as YouTube and Moodle. Recently, the ICT education market has introduced some new platforms specially created for entry operators in online training. These new platforms introduce full automation in the learning process and support of individual users (students), allowing significant reduction in the price of the end product.

Why VERTICAL?

2.1. Problems inherited from the classical academic curriculum

The classical model of academic education implies the realization of a unified multi-level concept in teaching, learning and use of knowledge. This model seems logical with regard to the course of development of the industry over the past 200 years, where engineers as well medical or law students can be effectively trained. However, this is not an adequate model for emerging technologies and services. The inability of this unified model to adapt new courses makes it incompatible with the current trends in the labour market. The concept of the unified approach is that the foundation of all engineering training must be obtained through compulsory subjects like mathematics, physics, chemistry, biology, electrical engineering, electronics and more. The problem does not lie in the relevance of such knowledge for engineers, but in the teaching these outside the context of their application. The classical structure of academic education programmes dictates that in order to produce an engineering professional, a 2- to 3-year study plan of fundamental education must be undergone. This classical academic approach leads to engineering and technology majors being considered extremely hard and boring by students. Moreover, the classical model of compulsory fundamental subjects leaves no room for the development of new and modern courses. Thus often the percentage of current courses does not exceed 30% of the total course count. During their studies most of the students in various engineering programmes continue to get the same basic format of fundamental courses, which form about 50% to 65 % of the studied material.

2.2. Modular – major and minor approach

The modernization of the classical university engineering programme is an extremely complex process. The difficulties come from the historical interdependencies created between disciplines such as physics and mathematics, electronics, electrical engineering and mathematics, biology and chemistry, etc. These relationships are "hollow" and, in fact, modern lecturers in mathematics rarely have a real understanding of what the application of the material they teach is. For many years university programmes have been devised by isolated specialists teaching highly diversified knowledge and who have no idea about the underlying physical processes of the technological courses they teach. This has created additional complex dependencies between completely "hollow" specialized theoretical courses and as a result the students of our day are not prepared for their future line of work. These dependencies on a fundamental level get less and less clear in the subsequent relationships of courses such as digital systems, strength of materials, microprocessors, etc. Over the years, curricula have been built by a horizontal structure method, each successive level presuming that students have successfully acquired the previous level of knowledge.

This multi-level structure concept is similar to classical engineering approaches used to building large buildings in the near past. The advent of technology has lead to the need for modern engineers to be trained in a large number of applied skills. However, these skills cannot find an adequate place in a curriculum that adapts very slowly to the changing needs of engineering training due to the pressure of the inherited relationships between courses. The current situation has resulted in large fragmentation of knowledge. The legacy of the unified academic approach, however, prevents the rapid adaptation of university programmes precisely because of the huge amount of horizontal and vertical interrelated subjects that the change cannot be done separately. For example the introduction of new technology courses implies that the whole technological background is covered. This of course is absolutely impossible and uneconomical. Consequently, the inclusion of a new technology in university programmes takes far more time than the one needed for its development, and after becoming obsolete even more time to be removed from that same curriculum.

To solve this problem, the modular training system can be introduced. The segmentation of the engineering disciplines today leads to a huge amount of nomenclature names for the same curriculum. In these programmes, foundation courses still account for 40% to 50% of the basic knowledge taught in all engineering specialties, some major differences lie mainly in the degree of use of disciplines associated with mechanics, electrical engineering or other technical disciplines (physics, chemistry, biotechnology, etc.) Due to the desire of universities in the past 40-50 years to engage the attention of as many students as possible, a huge amount of similar curricula that overlaps by 65%-70% were created. This diversification of education combined with the loss of a clear connection and analogy between seemingly different curricula today is causing the collapse of engineering education. At the same time, the last two years of study evolve into the modular model. However, university programmes fail to change the general structure of foundation courses. As a result, a number of university lecturers today, such as mathematicians, physicists and chemists, function in isolation, without a clear idea of their role in the creation of the final product. Today these academics appear to be a parasitic body of the same old structural concept. For example, few mathematicians have a clear idea and a desire to understand the exact application in engineering practice of the concepts they teach. The problem is similar with lecturers in chemistry, engineering physics, mechanics, etc. The highly theoretical courses in the first two years of study are the stumbling block of engineering disciplines. This fragmented type of teaching gives students an unrealistic idea about their future jobs. This leads to the destruction of the natural human concept for the implementation of education, namely, being of use to society, advancing in one's career and earning the respective remuneration in the latter part of an engineer's life. The situation is aggravated even further by the fact that using the Internet the modern student can easily navigate in the world of technology, while the university curricula gets more abstract and their usefulness is becoming less and less clear.

Another major problem of this modular approach built on common foundation courses is the lack of flexibility in order to build an open educational model that ensures the mobility of students and professionals in need of retraining. This historically obsolete approach cannot meet the current requirements of the labour market. It is useless precisely because it is clumsy and lacks interdisciplinary qualities. Moreover, it is closed and cannot be adapted to the needs of either the labour market or to the specific needs of the individual student. Using this foundation approach in education an engineer cannot re-qualified for a period shorter than two years, thus serious questions can be raised about the usefulness of such a qualification in the context of the ongoing development of technology. The separation of the various engineering disciplines in different nomenclatures without any real justification works only for public universities, whose funding is not based on market principles. These are state subsidized and aimed at preserving the jobs of a large number of senior scientists in dozens of different nomenclatures.

At the same time, universities are trying to become more attractive to their students by generating a huge number of minor programmes. This stems from the idea of reusing of existing product and selling it at lower prices, as low quality products, to customers who would not have bought it at the original price, but would prefer to get it within the total educational package. This model, however, makes the job of the university administration much harder worldwide, as every university within the last few years has started offering dozens or even hundreds of minor programmes in almost all professional fields. The seemingly cheaper for the end customer programme has become more expensive for the provider of educational services. Objectively speaking, this marketing gimmick to artificially maintain unprofitable programmes is as useless as a fifth wheel. The main idea of the possibility of continuous training and mobility is the ability to react to the requirements of the dynamics of the labour market, not to bundle educational packages for the sake of making them more attractive.

The buy-one-get-one-free model actually wastes resources by making the customer get something that she does not want or need.

2.3. Vertical versus horizontal

The ICT sector is the fastest growing sector of the economy. Innovations made in it, such as computer, software and electronic technology, have led to innovations in several classical areas such as mechanics, medicine, chemistry, physics, etc. The leading ICT companies were quickly to discover the inability of the classic academic model of education to prepare and re-train professionals in new and emerging industry areas. Due to these facts, a number of companies such as Cisco, Microsoft, VMWARE, HP, Siemens, IBM, etc., have created a network of internal corporate academies [3]. Moreover, by developing the role of their academies on a worldwide scale, they have managed to seize large market segments in their main activity: computers, networks, software etc. Typical benefits of the model these corporations use is its high efficiency, clear hierarchical structure and a clear picture of the necessary steps that a professional should take in order to be able to acquire a certain position and consequently to reach a level of remuneration. This model is completely different from the academic educational approach. It implements the vertical structure of the curriculum. This means that a network engineer does not need to know all the maths and electronics, but only the part of the technology with which she will work directly. However, when the level of his knowledge becomes insufficient, she can easily add to her arsenal of knowledge and skills acquired by doing other certification courses at the same or at a different company. It is because of its flexibility that this vertical model is particularly effective in conditions of high competition in technology. It is also modular because it implies a gradual stepwise accumulation of knowledge by students. Naturally, this model is open, as a professional can learn a technology from different educational providers, or to learn it by himself if he so desires. This makes learning open and accessible to a much wider audience, even to those with extremely low incomes, who generally have absolutely no chance to get quality education and training to ensure their professional growth and a better life. An increased quality of life should be a key element in leading the implementation of strategies for the development of higher education. That university, academy-style and individual educational service provider should provide such conditions as well as a set of technological tools by which the customer will be able to improve her social status and consequently her quality of life. This will make a number of curricula currently considered unattractive, anew interesting and preferred by students.

2.3. The verticalisation process is costly

At present we do not have objective information about how successfully the structural conversion in higher education can be accomplished. All we know is that this model works well in corporate academies and specialized training programmes on the market of educational services from third party suppliers. Historically shaped interconnections between basic disciplines in engineering programmes make them extremely difficult to reform. The main problem is not to convince teachers of the usefulness of this process, but how to make it as open as possible and providing the best mobility options for students.

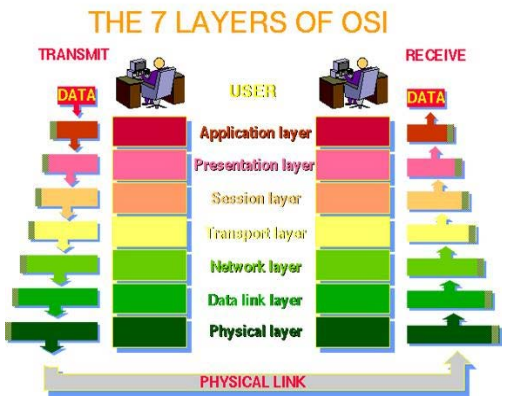
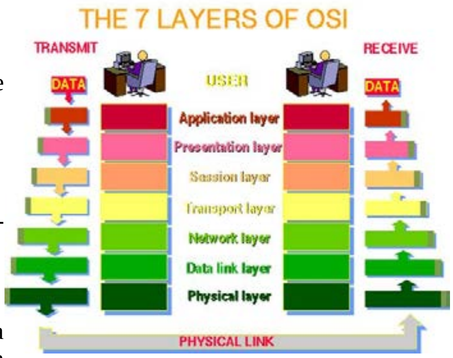


Fig. 1 *Studying technology must be very similar to a technology's internal architecture.*



Verticalisation can be partially achieved by adopting the so-called master classes, where a small team of lecturers take on the task to train a relatively small group of people in a specialized curriculum. This makes the final product very expensive, as it utilizes the resources of highly qualified specialists and occupies material resources that might otherwise be used by a larger number of teachers and students. To ensure mass scale in this approach and provide maximum openness, the individual courses should be interleaved not in separate blocks but in context-oriented strings of "elongated" educational units. This means that the model cannot be realized without online innovation. Without the online approach such training would be extremely expensive and inefficient. It allows online approach to create vertically oriented subjects that meet the specific needs of students and businesses.

We suggest the implementation of hybrid structural model curricula. In this process, some subjects may converge with other disciplines and also create a highly intertwined composite structure of knowledge and skills. However, for this to happen, we need vertical structural knowledge “pillars” and horizontal connecting elements, forming different levels of knowledge about the technology we teach. This approach allows us to create programmes in ICT that are open for teaching of technological subjects in the way that the technologies themselves are built Fig. 1. (ISO/OSI model on open interconnection between networks is a typical example of the realization of vertical modular architecture that can be seen as a whole and in the context of individual technologies.)

Why OPEN?

The vertical model combined with modular upgrades of the basic training programmes can provide the hybrid technology of teaching that is needed to open the market of educational services [2]. In this context, the presence of as many providers of specialized educational content as possible not only increases competition and affects directly the quality of training but also allows the construction of a specific ecosystem to better meet the demands of the labour market. So for example the implementation of the hybrid vertical - horizontal modular model will instantly set us free from the legacy of the classic fundamental model and Major - Minor modular approach. The vertical model of education will strengthen the role of universities and research institutions in teaching foundation subjects, but in a way that opens up these courses to the general public, making them more accessible, useful and effective for all users of the educational services market. For example, the teaching of mathematics, a subject highly specialized in vertical direction, will contribute to its proper use by students in their future work. In that way mathematics becomes a part of the growth of the professional, and an engineer will acquire new and relevant knowledge of mathematics where and when the need for this knowledge emerges. So when an engineer climbs the ladder of knowledge year after year he can be continuously supplied with specific knowledge directly influencing the quality of implementation of specific learning material in the relevant technological disciplines. This will get rid of the aggravating influence of fundamental disciplines and will make the engineering profession more attractive, useful and creative.

The NBU case?

In the context of the need to create attractive and truly effective curricula, the NBU was able to build a vertical modular curriculum model in several Network Engineering and ICT based programmes [4]. Within these programmes, we first created three vertical pillars on which we base our entire program structure. These are: mathematics, electronics, computer and software technology. These pillars start from the beginning of the study instead of concentrating on teaching of engineering fundamentals during the first two years; we develop and upgrade these disciplines vertically in the teaching process. This allows us to create a flexible programme that can easily adapt course modules acquired outside the university, as it does not interfere with the core support structure of the engineering education. Moreover the teaching of mathematics, electronics, and software in the context of specific technologies and their applications gives a very accessible form for students. In that way mathematics and electronics do not become obstacles in acquiring specialized knowledge, but rather they are a natural extension of the courses in specific technological fields. As a result, students learn more mathematics, electronics, computer technology and software than classical fundamental model. Moreover, this vertical approach can optimally be adapted to a variety of business-oriented courses such as the courses of Cisco, Microsoft, HP etc. Reforming the curriculum took about 3 consecutive iterations. The first pillar we erected was the one that ais most closely technologically related to communications – the electronics pillar. In this process in several consecutive school years the electronics courses were reformed so that today they are taught during the whole study of undergraduate students, up to the last year of study. The next iteration required the insertion of a separate pylon next by previous. It consists of courses in computer technology and software. By introducing applied courses as early as the first semester, the students get confident about what expectations and benefits they will have as a result of choosing this specific programme. Moreover, the introduction of this vertical professional model gives students the outline of concrete knowledge and skills they need to start work immediately. The most complicated step in reforming the curricula was the verticalisation of the foundation of mathematics. Being the most important subject, mathematics requires the longest time for reform. As a result, however, we have created a very applied curriculum and from the beginning of their studies, students get a clear picture of the application of mathematics for solving specific technological problems that they will encounter in their future practice.

Conclusions

At present there is no universal model of the successful accomplishment of the structural conversion in higher education. All we know is that this model works well in corporations and that apparently it can be applied in higher education. However, the advent of this innovation will lead to a number of difficulties related to regulation. It is possible that regulation regarding programme accreditation at present will be reoriented towards accreditation of specific courses: pillar, modular, horizontal and caulking. It is also difficult to imagine without appropriate computer models how these will work in a hybrid model. At present, the authors hope to achieve a wider popularity of the proposed vertical model of innovation in higher education. We think this will strengthen the role of higher education in the process of training and retraining of labour resources. The main driving factor here is the focus on technology, the variety of technologies used in higher education, creating consumer-oriented education through the introduction of online innovation in higher education.

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