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A Way to Introduce Innovative Approach in the Field of Microelectronics and Nanotechnologies in the Chinese Education System

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Abstract

The innovation is more and more useful in order to develop new products such as the connecting objects. The field of microelectronics is particularly concerned by them since it combines the fast evolution of the technology, and their application to many domains. The educative system in China is mainly based on memorization of knowledge: the students are lacking of methodology, understanding and practice. In the same time, the pedagogy in higher education moves progressively towards a numerical approach. In this context, the main challenge is to give to the students, the methodology, the know-how, and thus an innovative behaviour. In this way, several suggestions are given: introduction of much more works on applications of the theoretical knowledge, training on the linking of knowledge, and improvement of the practice by laboratory works on dedicated platforms.

Keywords: innovation, higher education, microelectronics, practice and labworks.

1. Introduction

The economical world encourages more and more innovation in order to develop new products that should answer to the future societal needs, more especially the connecting objects. The field of microelectronics is particularly concerned because these objects combine the strong improvement of the microelectronics technologies, and the application to many domains. In the same time, the pedagogy in higher education shifts towards a numerical world by involving tools based on Massive Open Online Courses (MOOCs), internet sites, modelling and simulation. The main challenge is to give to the future engineers, the methodology and the know-how, which is not enough provided nowadays, and thus an innovative approach. The pedagogical approach in China, from the primary school to the University, is based on the learning of knowledge, mainly. The evaluation and the selection are based on the memorization as well. Several weaknesses are revealed. This paper highlights these points and suggests several improvements in order to give to the future engineers an innovative behavior in the field of microelectronics.

2. Situation of the Higher Education in China

The previous experience in China of the authors shows that the basic education presents several weaknesses in the pedagogical methodology. On the one hand, in the learning of basic knowledge since the primary school, the pupils, then the schoolers, and finally the students are spending a lot of time learning by heart a difficult language, and, with the same approach, the scientific background (mathematics, physics, chemistry, etc.). On the other hand, they have a low amount of practice, including applications of theories through resolution of problems, and a very low amount of laboratory works. But this practice is revealed very efficient to assimilate more the methodology and the logical demonstrations than the theoretical knowledge. If the memorization by heart is efficient to give to the

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students the good capacities of communication in their national language, however the students lack a general approach that allows a deep understanding of a scientific field, and also the link of knowledge between several fields.

In the frame of 1000 Talents program of China's Government, an analysis of the situation in the field of Microelectronics raises additional weaknesses, specific to this field. Indeed, due the very expensive equipment for devices and circuits, the students have in average a very poor know-how. In addition, because this domain has a permanent and very fast evolution, the practice can be always obsolete if an innovative strategy is not applied by the institutions and their educational departments. These weaknesses give rise to some suggestions that can improve the efficiency of the acquisition of skills in this domain.

3. Evolution of the Technologies

The very fast evolution of the microelectronics integration since more than forty years is well known and is called the Moore's law [1]. This heuristic indicates the decrease of the transistor size as a time function thanks to the tremendous improvement of the technological fabrication processes and to the huge increase of the performances of the computer tools and associated software. These improvements have later opened the doors to the system integration, called the "More than Moore" evolution [2]. It corresponds today to an increase of the complexity by combining several technologies and the packaging capabilities, by mixing other functions than electrical ones, and by designing the elementary devices and the integrated circuits in three dimensions. This evolution induced new generic technologies such as mechatronics, optoelectronics, bioelectronics, systems-on-chips, large area electronics, etc. that combine skills in several fields and that are intrinsically multidisciplinary [3]. Indeed, these new concepts are already applied mainly to the sectors of health, environment, security, energy, agriculture, transport, and communications, which are considered as the first priority for our future technological societies. Thanks to the concomitant strong evolution of the communications, through internet, through wireless communications such as Wifi, ZigBee, Bluetooth, 3G, 4G, cloud, etc., it is predicted a fast evolution towards connecting objects in all the mentioned applications. Many reports made by international experts highlight this evolution for the next ten years [4].

4. Innovation Approach Linked to Microelectronics

For the design of these connecting objects, the engineers in research and development centers must combine the knowledge and the know-how of several fields and must be innovative. This innovation may come by the capabilities of the designers to analyze the economical and societal needs, to make links between technologies, to extract the concepts of existing applications, to apply the selected concepts of one field to another one. All these qualities and know-how should be initiated during the studies. In other words, this means a high knowledge and the know-how that allows the control of the limitations of the systems, the definition of the adapted mission profiles, the control of the security of the equipment and of the effective application, and the reliability as well.

This supposes during the studies a very good background in scientific disciplines, a good training including practice and laboratory works, and a multidisciplinary approach including the capacity to establish links between the different fields (communications between engineers, understanding of the concepts, etc.).

5. Expected Evolution of the Higher Education

Many governments of developed countries try to develop the numerical approach of many branches of the economy, and more especially the education one. Thanks to the huge increase of the performances of the digital tools associated to the powerful computing capabilities of the hardware (microprocessors, DSP, etc.), to the size of the software, new educative tools can be created. They can contain texts, pictures, animations, videos, but also simulations and modeling. If these tools can be really useful to make easier the comprehension of the basic knowledge, they appear insufficient to understand the methodology, to make links between knowledge and above all they remain virtual. The functioning of connecting objects is often very different from the one of virtual objects. The main reason is the complexity of the environment that can affect the functioning of a product, for example, effects of the temperature, the pressure, the chemical environment, etc. The natural environment is so much complex that it is very difficult to guarantee that a simulator takes all the parameters into account! Thus a complementary practice is mandatory in order to well understand the limitations, the range of the physical parameters, and the mission profile. This practice is also a way to better explain the fundamental background, to give a know-how in real situations that is a key approach to develop the skills of analysis, of synthesis, of making links between several disciplines. This approach allows the building of an innovative behavior of the students.

6. Suggestion of Evolution of the Chinese Higher Education

Many suggestions can be made in order to improve the innovative approach [5]. We mention those that can be the most efficient in the present situation. The first concerns the methodology of teaching that should not be mainly based on memorization but that could include problem solving, cases studies of real objects and their limitations of functioning. The second point is focused on the need of practice. In the field of microelectronics, due to the high costs of the software and of the technological facilities, the set-up of common platforms should give a solution. This approach was developed in France since many years in the frame of a national network [6-7]. Twelve national centers receive more than 14.000 students per year in technological cleanrooms, on benches of physical and electrical characterizations, on platforms of modeling, simulation, and computer-aided design. Moreover, an innovative strategy of the network is applied through annual projects in order to maintain an up-to-date training.

7. Conclusions

Several weaknesses were observed in the Chinese education system: they seem to have an important impact on the learning of the microelectronics discipline. The introduction of new approaches that include much more analyses, understanding and acquisition of know-how should lead to a more efficient learning adapted to the permanent innovation needed in this domain.

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