A Review on Education of Electronic Engineers Emphasized to Teaching of Measurement Skills

Božidar Dimitrijević, Chair of Measurement,
Faculty of Electronic Engineering in Niš

Abstract: A brief review on the electronic engineer education and some idea how to exceed noticed defect in this education process is presented in this issue. According to the content of articles from foreign magazines and from internet addressing to this subject, one can be seen that education reform in general is very actually theme all over the world. Pressure to change the present education system arises from the fact that there is a disharmony of low efficiency study in versus a sudden and rapid growth of new technologies, especially information technology. Relevant questions are what skills and experiences might an employer in industry look for in a future electronic engineer and what electronic engineers should to learn in metrology.

I. GENERAL OBSERVATIONS

When my esteemed colleague prof. Vančo Litovski invited me to prepare my contribution for this colloquium I did not have any inkling of what problem I accepted. Even though I was given the intention of what should have written, the theme is still too more complex. Namely, there are so many entangled factors that impact the faculty education system. As we get down to essential reform education of electronic engineers, those factors can not be neglected. Changing only the curriculum and syllabus of courses is not sufficient, but the radical reform of the position of all education associates and other sociable factors in relation to realisation of the curriculum and its syllabus is certainly needed.

For that reason, it is necessary to get the answers to certain as it seems simple questions that can not be obtained only from direct associates in education (academic staff and audience), as follows:

- Who needs electronic engineers - is it nation's need, assumed unknown user, or both?
- What profile and which level skill graduate engineers would be educated in, that is, what working market is expecting from each future graduate electronic engineer - is it industry, service sector or something alike?
- What annual number of electronic engineers is needed for some estimated time in the future and who will pay for their education?
- Who and how might educate electronic engineers?

The above questions may seem simple, but if there is no answer then every education reform will be based on the assumptions that will not be of any concern, as it has been proved in practice, and any reform efforts concerning education process will be in vain.

Thus, in our country, within branches of electrical and electronic engineering in the long run there must be a defined development strategy of the industrial and service sectors as well as economic including long term real needs for this kind of workforce. Of course, besides other participants, all universities should be helped in defining this strategy and each of them entails its own set of tasks and responsibilities. Also, without new improved experiments it would be preferable to use experience and the achievement of developed countries, especially the one in transition that might be gradual implemented suitable our needs.

Thanks to the Internet and other magazines that I get as the IEEE member, I have noticed that a number of papers in magazines and on conferences in the world deal with reform, that is, with a new project on engineering education, especially for test and measurement (T&M) designers for the new millennium[1].

At the end of the last century and beginning the new millennium, from the point of the global world view a number of proposals and projects on engineering education have been initiated, as it is estimated that the present state of education system can not satisfy the requirements of modern industry as well as economics. It was especially impacted by sudden and rapid development of the information technology in almost all human activities, particularly in the field of communication and global international goods and service trade. Also, the development of the information technology is affected by the rapid progress in microelectronic and at present even in nanoelectronic technology that results in the achievement of computer science and engineering.

Some estimates are shown that for any important electronic product development, the software effort is usually significant, even about 40% or more of the total engineering effort. On the hardware side, the amount of digital circuitry especially has increased, displacing analogue circuitry with the mixed-signal mode integrated circuits, as the cost per digital gate has plummeted. From there, employers and economists of industrial companies have many problems to achieve strategic advantages through development design of their products that must meet standards to modern industry from viewpoint of quality, reliability, effective price and smaller size.

On the other hand, in spite of that large engineering progress, an economical estimate has shown that the global world's economy over the recent past have had serious problem to accomplish the growth of productivity despite to much investments for information technology both in production of goods and service sector.

Nobel Prize-winning economist Robert Solow has pointed that "we see computers everywhere except in the productivity statistics". That productivity measures do not seem to show any impact from new computer and information technologies have been labelled the "productivity paradox." Productivity growth has slowed every decade since the 1960s while investments in information technology have grown dramatically. Some take this as proof that information technology doesn't affect productivity[1].

In that conditions, education system particularly in engineering disciplines may not be insensitive both to that no expected occurrences in economy and in respect to educator's responsibility, so that there is a real pressure in the world to undertake thorough analyses and to carry out a necessary reform of education process, disregarding an extremely dynamic progress of that branch.

What scope of changes have been undertaken in the our education system only through the last 50 years one can see from one of the facts that in the 50's of the last century in Serbia was only one general education profile of electrical and electronic engineering labelled as graduate engineer of electrical engineering. Later, this profile is branched to two profiles: graduate engineer of electrical engineering with the majors of energetic and telecommunications.

Since the foundation of the Electronic Major at the Technical Faculty in Niš (1960), later separated into the Faculty of Electronic Engineering (1969), out of the general profile of the graduate engineer now we have six new profiles: automatics, electronics, industrial energetic,

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[1]http://www.neweconomyindex.org/productivity.html

computer engineering with informatics and telecommunications. Today, almost all faculties of electrical engineering educate graduate engineers for five to six different majors, and among them electronic major. Through study, these profiles are based on the fundamental theory on mathematics, electrical engineering (electromagnetic and circuits theory), physics, electronics and some measurement. From the second year of study, every particular education majors have own professional coerces followed by the final examination.

II. ON PRESENT EDUCATION SYSTEM

A critical point in this approach to engineering education is depth of analysis for each section in basic subjects. There are always the simplified examples for explaining certain rules or methods using only letter symbols, such as avoiding numerical calculus or giving explanations that are too general or too indefinite. Those methods give students only qualitative results, but not quantitative as measure of value that results so the audience have not skilled sense of quantity value. Defect of knowledge caused in that way is inversely proportional to the audience experience. While this kind of education might be acceptable for an experienced audience, as at postgraduate study, at undergraduate it is absolutely unacceptable [2].

The qualification of our graduate engineers according to the current curriculum and syllabus at the existed study is on the scholar level of theoretical knowledge as much as it is needed to only pass examination. To pass examination, more students are accommodated with demands of their teaching staff by using usually the questions and tasks for preparing their exams from previous very frequent examination periods. Learning (no study) is mainly by means of taking notes on lecture, from teacher's textbooks and exercises and from other similar attainable publications. Relationship and coordination between particular syllabuses are very poor and gradual and sequence of taking exams is not respected. In very often cases, students at final years of study got through their back warded exams from the first or second year of study. From there it is evident of what importance the exams that represent the base for studying the following subjects are.

Taking into consideration (none) supplying of laboratories and their treatment at faculty, practical education of students at laboratory exercises is not at all satisfied as real needs of moderate techniques and economics are concerned. Non adequate concern for practical education is resulted mainly out of the subjective reasons. There are teaching courses within the engineering profile which curriculum anticipates practice exercises, but they are not performed or are performed on very poor level by the obsolete teaching means and according to the usual custom.

Knowledge of this kind without practice exercise may have been sufficient at one time when graduate engineers after having got a serious job at first position they had a possibility to gain paying time for their additional creativity skill through advanced training at their position or at other well-developed companies. This kind of education in contemporary market competition is not so economical, but graduate engineers are expected to be immediately engaged on a profitable jobs where the index of success of their applying skill in practice is estimated by quality, price, period of goods and services disposal and finally by gain of profit.

III. WHAT PROFILES OF ELECTRONIC ENGINEER

This topic can be formulated in detail by a question as follows. What and how should the graduate electronic engineer learn to satisfy the needs of his profession scope from an idea to finally realisation of the subject work (product) on his job in industry, service sector or sector of special purpose?

From the viewpoint of technological development in the long run, the work subject in electronics include production of goods and services of vital importance for our daily way of life and work and are based on electronic technology and engineering, from sophisticated equipment used in a modern hospital to state-of-the-art fibre optic communications. In the working world the dominant place in the range of this profile nowadays take computer engineering, telecommunications and consumer electronics.

In our case, what is expected of the electronic engineer now and in the near future probably is as follow:

- innovation work on existing non-competitive (obsolete) products to new products that may satisfy the present needs, first of all on the contemporary domestic market,
- application of the new techniques and electronic technologies in public service sector,
- transfer of technologies for production of goods and services according to standards in relative stable markets,
- cooperative works in industry and in public service sector that meet standards of the wider region,
- another less range works for special purposes.

Therefore, to define profile of electronic engineer directed to one subject work type is not so simple. Graduate engineer may find himself at all phases of electronic production in the row of tasks like design, development, setup of production process and providing assign quality level to both production process and final product. To meet all these working conditions, graduate engineer must be skilled in knowledge in reference to function, characteristics and possibility of moderate typical microelectronic components used in all kinds of electrical signal processing (analogue, digital and mixed-signal) over all frequency range.

The application range of microelectronic component and circuitry on products, resulting in interdisciplinary expert team, is wide. Basic tools that skilled engineer must be able to use are typical software tools and electrical and electronic measurement and test equipments. For that reason, the adequate balance is needed between necessary knowledge in the electronic components, circuits and systems, on one hand, and on the other hand the knowledge in using the proper tools, that may be achieved only through practical education.

Practical experiences of an engineer have a particular importance, because at solving some occurrences in production design, the general and long-term exhausted analyses of known problems are of any benefit. For solving the problems of the impact of the mutual interconnection, shielding, grounding, noise reduction, crosstalk and other like, practical experience and skill is preferable than theoretical knowledge. Engineers for those jobs have to be educated in laboratory by the real practice solutions rather than they have been satisfied only with obtained results by means of software simulation tools. Nowadays, from the viewpoint of profit and market competition, long term engineering education over the training period in industry is not economically acceptable. Preparing, introduction, maintenance and control of both production process and final product require from graduate engineer to know all jobs shared for skilled worker, craftsman of service, technician, associate degree, bachelor degree, and he must be able to use engineering documentation and literature from the field of his profile.

Therefore, a necessary graduate electronic engineer may be obtained by means of effective study that means possible shorter time of study and a narrow scope profile according to the needs of contemporary market. Engineering education requires a balance the need for skill that can be applied immediately versus a strong foundation in applied mathematics and science. Engineering educators are obliged to maintain this balance. Employers have the same dilemma – the need for new hires that can jump right in versus engineers prepared for the long haul[3].

The various engineering professions are easiest to define if we follow the process by which a new product is developed, manufactured and practically used. The positions of electronic engineers according to the traditional roles are: *test engineer*, *design engineer*, *product engineer*, *systems engineer* and *service engineer*. Although these engineering professions are involved in the development, production and service of electronic products, each profession entails its own set of tasks and responsibilities. Putting to work the graduate engineer as service engineer is not economically acquitted because this job can be successfully done by the skilled technicians or person with associate degree level. But, under our circumstances most of the graduate engineers now get a job in service sector or they are unemployed because the industry has been in economical crisis for a long time.

IV. INSTEAD OF CONCLUSION:

Whether measurement in electronics or electronic in measurement

In spite of the fact that measurement is unavoidable activity at almost any technological process in both industrial and public sector, it is not a sufficient reason for introducing a separated profile in our engineering education system based on the measurement science - metrology. In the scholarly circles and wide expert public there is no dispute with certain significance of metrology as one of a primary measure of technological level of every country, but some visible interest in studying measurement as separate discipline is not noticeable. In addition, the lack of familiarity with term "metrology" confused by term "meteorology" restricts interest for the subject education.

Some of the possible reasons are spreading of metrology in all branches of science and technique and the large volume of competencies for expert metrologists. Besides, many experts in their fields usually consider measurement simply to be something one must do in the engineering. Because they have a conceited but naive reason: “If you understand the scientific principles of a technology, you should surely be able to measure the parameters in that technology, and measurement uncertainty is much ado about nothing” [4].

Metrology education at the Faculty of Electronic Engineering in Niš is only a small part of the general theoretical and practical measurement aimed to the basic principal of electrical and electronic measurement. Although over the last two decades, continued innovation in information technology has completely changed the field of electronic instrumentation and measurement, the curriculum of graduate electronic engineer has provided less than 3 percent of total classes during all of study. Can there be enough time for student education on basic, legal and applied (industry) metrology?!

Therefore, only this fact is sufficient to conclude how metrology education is important for acquiring skill of the graduate electronic engineer which should tomorrow do as test *engineer*, *design engineer*, *product engineer*, *systems engineer* or *service engineer*. The various jobs functions of an electronic engineer in metrology are easiest to define by examine the process of development, production and quality control of product.

In the world, it is noticed now a tendency to profile forming of engineers as a generalist (able to adapt to new technologies), a specialist (in command of the current technologies), and a practitioner (competent to perform both generalist and specialist work in a modern industrial context). Each of these categories should be supported in engineering education through relevant course content available in lecture, laboratory, and project formats [5].

Every electronics course should contain elements of measurement and uncertainty analysis, and uncertainty analysis should also be taught as a course. This approach will bridge the gap between courses taken at other schools without adequate attention to uncertainty, and a strong metrology curriculum which emphasizes uncertainty analysis in every measurement. Graduates might have broad degrees in mechanical, industrial, or electronic engineering technology, with a metrology specialization. These degrees will have the versatility to stand alone in any job market, including metrology, and the student will be able to “hit the ground running” in any metrology or test laboratory environment.

Certainly metrology laboratory technicians, engineers, managers, and ISO assessors from government, military, and private organizations are prime customers in the workforce; but so are teachers and students in the secondary school systems.

Why should students know the systems approach to electrical/electronic measurement? The answer to this question has been done by authors of cited paper [6]. They said: "we should start by considering the skills required of an engineer in general, progressing to those of an engineer using and/or designing measurement system. A closer look at the design process will help us to orient the answer and to see how the system approach to electrical measurement may constitute an appropriate background for development of the skills required of a measuring system specialist".

In measuring whether in order to troubleshoot an existing circuit, to characterize and define a new circuit, or to find the value of some other physical variable, many of applied science and engineering in general, and of electronics in particular, have been involved.

In general, a common task is to find appropriate solution how to use some electronic means to make a measurement. Questions like what, how, by means of what and why measure are fundamental in measurement and answers to them might be given only in theory of measurement. It is the naive sense that is possible to measure something and to use the information gained for some particular purpose, without knowing much about measurement theory. But, there comes a case when it is necessary to understand a little more about it in order to gain the maximum utility from the performed practical measurements.

Modern instrumentation embedded by digital signal computer can provide high performance of automatic calibration, measurement data processing and communication. This complex equipment may be used without detailed knowledge how it works and what it measures. Once the measurement data from object of measurement has been transferred to digital form, its accuracy and number of significant digits no longer important. Measurement data is obtained too easy using the computer, but many digits of data row convey a false sense of accuracy and information. The real danger for students is that it is too easy to play using software simulation that acts more like a toy than a serious tool. What this means is that students are enjoying an easy-going life in the dimensionless, virtual word of a computer simulation, but are not learning enough about the real, dimensioned world where they must practice engineering. Valuable measuring data can be obtained only by carefully examine of measurement condition, accuracy, uncertainty and resolution. The only cure for that is a systematic approach to I&M education that includes improving basic understanding of the natural sciences [7, 8].

It is vital to recognize the importance of measurement as a complete process, including the concept of uncertainty analysis. From the metrological view point the study of metrology is the study of measurement uncertainty giving answers how to avoid it, how to minimize it, and how to quantify it.

Finally, whether measurement in electronics or electronic in measurement is left open question for educators. In order to point out in what way engineering teaching should be improved I proposed to my colleagues to read the paper: "Implementing the Seven Principles: Technology as Lever’’ by Arthur W. Chickering and Stephen C. Ehrmann, on website: http://www.aahe.org/technology/ehrmann.htm#Top

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