Chapter 21

The Importance of Practical Activities in the Formation of Mechatronic Engineers

The globalized job market needs engineers who have practical knowledge, and who can solve problems quickly, when they start their professional activities. Generally, it is very difficult to find newly qualified engineers who have the above characteristics. Traditionally, higher education focuses principally on theoretical training. Despite the difficulties encountered in changing the traditional structure of higher education, in which there has always been a clear dissociation between theory and practice, universities are now trying to improve the quality of teaching, and to meet the demand of the current job market. Practical activities are a differential that adds quality to newly graduated mechatronic engineers. It is essential that the students participate in extracurricular activities such as research projects, and visit companies involved in their specific field of activities. Thus, this chapter presents and discusses the importance of curricular and extracurricular practical activities for the training of mechatronic engineers, in order to prepare them for the current demand of the globalized job market.

21.1. Introduction

Since the beginning of civilization, humanity has dreamt of a better life. This has often been done through projects and the creation of systems to

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simplify life, to seek pleasure and wellbeing and thus to promote what we call "progress" and "development".

This development has been possible, thanks to new inventions, technological advances, scientific discoveries and advancements in all areas of human knowledge.

It can be affirmed that in modern human life, in any environment, most of the elements therein, have directly or indirectly been produced from the knowledge of engineering. In this sense, a great challenge to the formation of engineers is related not only to their technological knowledge, but also to their preparation in order to be able to contribute to the solution of urgent problems by applying technological innovation to improve the quality of life and to promote peace.

Among the engineering courses, mechatronics engineering, by its own definition, requires a horizontal training of professionals, as it involves various areas of knowledge. A scheme that very well characterizes all these involved areas of knowledge was proposed by Professor Kevin Craig as shown in Figure 21.1. This means that mechatronic engineers must have a strong basic formation in mechanical engineering, electro-electronics, control systems and computing. Knowledge of these systems can be used in the development of mechatronic systems for application in many areas of modern life. Mechatronic engineers also use knowledge of materials and of mechanical sciences associated with measurement, management and production techniques to create various types of products.

In discussing the teaching of engineering, and especially of mechatronics engineering, in a globalized world where unprecedented technological changes are causing transformations in our society, leads us to rethink pedagogical practice for teacher formation and the formation of engineering professionals. Technology education has recently been the target of vehement criticism and questioning. This may be due to the fact that we are using the educational models in a rapidly changing world, which have been created in the last century.

It would be reasonable then to assume that education technology should discuss, in parallel with specific contents, science, technology generation, its doubts, fears and the impact that it has on all of us. Unfortunately, this is not what is perceived by teachers, students, professionals and other representative sectors of our society.

The historical and social dimensions in the understanding of science and technology must be introduced. Despite the importance given to scientific and technological knowledge, much of the world's population still goes through unjustifiable problems and needs, even when the technical possibilities to solve them are available. We can imagine then that reflections and adjustments in the technological education process will contribute significantly to improving this situation.

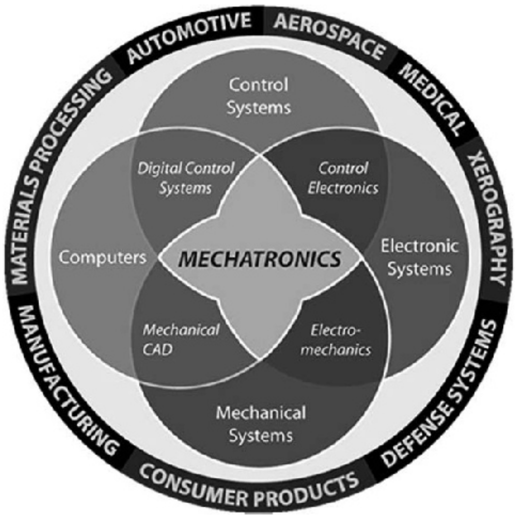

Figure 21.1. *Definition of mechatronics (Professor Kevin C. Craig; Greenheck Chair in Engineering Design & Professor of Mechanical Engineering; College of Engineering, Marquette University, Milwaukee, Wisconsin 53201-1881; http://multimechatronics.com)*

Engineering schools and universities have a great responsibility to organize their curricula so that their graduates and the population in general can take advantage of the speed of technical development. In general terms, the great challenge to the curricula is to prepare young engineers simultaneously in the fields of physics, mathematics, computer science, the environment, the humanities as well as in the specific area of formation in mechatronics engineering. Mechatronics engineering entails the integration of expertise in mechatronics engineering, electrical-electronics, computing and control systems. The curriculum should not be focused only on solving specific industrial problems, or solely on training the students to be mere users of existing technology [CAR 11, HAB 06, HAB 07].

The solution to this problem is not simple, especially considering that many products that we use today did not exist until recently. So, what the population will need in the near future should be included in the development of a mechatronics curriculum. Since the answer is not simple, Bevilacqua [BEV 09] summed up our situation as: “We are simultaneously observers and former users of objects displayed in a Science and Technology Museum”.

Another problem is putting a curriculum in practice: giving the students the most important information about the area in such a short time. Moreover, the curriculum must also take into consideration cultural, national and institutional conditions.

Howell [HOW 09] says that a curriculum in engineering may diverge from considering important aspects: “strong fundamentals vs. innovation and problem solving; individual excellence vs. team interactions; preparation for academic vs. industrial careers; research vs. application; solution of “traditional” vs. open-ended problems; and others. The best curriculum for one institution or country may be very different from another, depending on the perceived relative importance of these factors”.

Indifferently to the type of formation or curriculum, young mechatronic engineers must have a well-founded formation to be able to work in multidisciplinary areas, develop creative ideas and be ready to face new complex and interdisciplinary problems.

In this chapter, the authors discuss the issue of inclusion of practical activities in mechatronics engineering education. Some aspects correspond to professional experiences in developing the curriculum of mechatronics engineering at the Federal University of Uberlândia, Brazil. Teachers for approximately 30 years also have experience as course coordinators of engineering and in discussions in this area as members of ABCM – Brazilian Society of Engineering and Mechanical Sciences and IFToMM – The International Federation for the Promotion of Mechanism and Machine Science. Then, as the development of a curriculum in mechatronics engineering is not a “black box” where the contents are already predefined and defined, it is subject to controversy and criticism.

The systematization of technical education in Brazil has in its history models of French technical schools from the 17th and 18th Centuries: The *Académie Royale d'Architecture* (1671), the *École Nationale des Ponts et Chaussées* (1747) and *École des Mines* (1783). These schools represent the first "civil" engineering schools in the world. In Brazil, technological education was introduced by the Portuguese in the 19th Century.

Until the 17th Century, it was the responsibility of the school to enable people to deal with subjects such as reading, writing, calculations, religious dogmas, philosophies and civil laws, according to Petitat [PET 94]. Technical education was introduced in the 17th Century. This teaching model was independent of traditional ways, which began the approach-applied work that consisted of an extension of technical and scientific practices in schools.

A great novelty introduced by the technical schools was education beyond things in themselves (objects and phenomena of nature), and much closer to theoretical models (mainly based on mathematics), that is idealized representation. Thus, a technical-scientific discourse was established allowing a practice of observation that penetrated experimentation in teaching. It is interesting to note that modern science took shape at the time of the Discourse on Method, by René Descartes, and the *Principia* by Isaac Newton.

In the first engineering schools, formation was more geared to specialized functions for the state, not for private productive systems. Thus, the state monopolized the new process of formation of technical professionals with power posture knowledge and a certain autonomy. It is in this context that these schools arise and establish themselves, causing and affecting changes in the educational system [CAR 03].

Engineering education in Brazil has foundations linked to the positivism of Auguste Comte. In the 19th Century, Brazilian engineers participated actively in the discussions between orthodox positivists (willing to promote a profound moral reform of society) and heterodox positivists (concerned with the definitive establishment of positive scientific knowledge in different areas). Most of these engineers opted for the second aspect, and it is thus inherited today and revered as a premise by individuals with technical formation. Heterodox positivists part from the understanding that students are empty containers having no knowledge; the teacher will fill them with their experiences and treatment of scientific knowledge, which is ultimately necessary for the intellectual pretensions of the human species [BAZ 00].

Engineering education is characterized by great fragmentation and hierarchy, especially in Brazil. Courses are divided into approximately two cycles, the basic and the professional, or when establishing sequences there are very strict prerequisites among the various disciplines giving them a rigid sequence.

When it comes to engineering education, approaches and challenges related to the usual model of education reveal an amateurish posture that is often devoid of the rigor reserved for other professional procedures. Sporadic surveys conducted by individual educators worried about the problems of engineering education are, not rarely, devoid of theoretical analyzes that can deliver more consistent, realistic and promising new developments.

In engineering courses, the formation of technically capable individuals with a social, critical and creative vision is not suitably realized. Once this fact is verified, discussions among educators revolve around attempts to schedule a balanced distribution of technical content during the semesters. This task performed without proper diagnosis and without any didactic-pedagogic foundation (at least theoretical) will show, for certain, a certain distance between the desirable and the practical performance of everyday life. In general, the teachers are engineers, and the majority of them have postgraduation experience in engineering, but has no didactic formation.

Generally, the engineering curriculum is separated into two parts. The “basic cycle” that aims to “give” the students the fundamentals required for the next cycle. In some institutions, the “basic cycle” is offered separately from the institution responsible for the formation of engineers. It is not uncommon for the teachers of the basic cycle to lack the knowledge of how the topic given in their discipline will be applied in engineering. In practice, it has been observed that these contents have frequently been considered as if they were an end in themselves with no logical application in engineering. As in the professional cycle, in many situations, the informative process is given more importance than the formative process, and presupposes the knowledge given in the basic cycle and its projection for future professional performance; a projection that every teacher has regarding the market that is often stereotyped.

Despite attempts to improve and change the curricula of engineering courses, what is clear is that from the outset there is a blatant dissociation between theory and practice [BRI 93], focusing a strong theoretical content at the beginning of the course.

It may be noted that teachers in some countries have been concerned about this problem, focusing on efforts to improve their teaching programs in engineering. However, it is often possible to note that their concern is much more about the quantitative aspect than the qualitative aspect and lacks curriculum consistency.

In this context, the importance of curricular and extracurricular practical activities in the formation of mechatronic students that should enable them to be more participatory and creative will be presented.

21.2. Curricular and extracurricular practical activities

In this chapter, practical curricular activities are obligatory under the flowchart of the course, and extracurricular activities are those in which students can participate, or not, depending on their affinity and/or interest.

The practical activities allow engineering students to learn, making them critical, creative agents interested in staying up to date to meet the challenges of their profession.

In general, some advantages of the practical activities can be summarized as follows: to consolidate formation in the basic disciplines of the course, either in specific activities or in interdisciplinary activities, thus enabling multidisciplinary integration; to promote the understanding of fundamental scientific principles and their role in the structure of engineering and to develop communication skills and relationships; to develop the habit of self-improvement and education after graduation; to develop the ability to create and to improve systems and methods; to develop the ability to work in groups to solve engineering problems that encompass technical, economical, political, social, ethical and environmental aspects.

Consequently, mechatronic engineers, so formed, may act in the design, implementation, operation and maintenance of automated production units and development of intelligent products taking into account the economics, management, security and environment. In addition to technical formation, university education should prepare professionals to be able to think and act by themselves. They must also have initiative and be prepared to take responsibility both at the social level and in their specific area of expertise.

It should also be noted that it is important for students to get experience in practical activities from the beginning of the course in order to encourage them to develop their knowledge in their area of expertise.

The following section presents some practical activities that contribute to the formation of young engineers.

21.2.1. *Practical laboratory activities*

In general, practical classes that are conducted in laboratories are associated with academic disciplines, even when they are separately included in the flowchart of the course.

The practical activities conducted in the laboratory aim to complement the content of lectures and learning. To achieve its goals, this activity should not only be in the demonstratable form. The students should be given the opportunity to effectively perform the planned activities. For good results, two students should work on each bench directly monitored by the teacher or the person responsible for the activity.

It is debatable whether it is better to have the classes conducted in research laboratories or in specific class laboratories. Each option has its advantages and disadvantages.

The research lab has the great advantage for students in letting them experience *in loco* new technologies and procedures. Being in the place where research is carried out, the students would have the opportunity to use ultramodern equipment. However, there has to be good programming because laboratory classes would interrupt research activities. Another disadvantage is that the students are not allowed to remain in the laboratory at the times that are not provided for their activities.

In turn, although the specific laboratories for teaching activities have a place and a time reserved for course activities, in general the components used by the students are not the same as those used in industry. This conveys a sense of disassociation from what is really used in practical applications in industry. Another feature that has been noted is that these labs typically have their installation and equipment underutilized. In this sense, it is important that the space should be designed to meet the various laboratory practices, and that the entire installation, including the support staff, should be well organized. Another aspect, although more difficult to implement, is that young engineers should have the opportunity to use industrial components that will be necessary for their professional lives.

21.2.2. *Monitoring*

Monitoring is an activity in which student-monitors help teachers to guide other students, to solve problems. To get good results in this teacher–student association, it is necessary that the student-monitor should have passed successfully the course in the particular discipline and know how to relate well with other students.

This activity allows the student-monitor to deepen his knowledge in the discipline, to show initiative, and to communicate and express himself with ease.

21.2.3. *Research initiation activities*

In research or scientific initiation activities, the student is enrolled in a research project coordinated by an experienced research professor. The students should be given assignments that must be developed in a given time. When involved in such assignments, the student has the opportunity to live with scientific procedures. This activity greatly develops the formation of the students, as they should always be studying, learning and incorporating new knowledge; the activity also helps them to be at ease in communication and expression, both in the written and spoken form; it should also permit them to have individual and teamwork leadership, and the ability to use computer technology to solve engineering problems in a systemic way.

This type of activity can be developed from the beginning of the course as many jobs consist, for example, of graphical and numerical simulations, where the student can easily learn a new programming language.

21.2.4. *Participation in junior companies*

The idea of the Junior Company emerged in France in the 1960s. In Brazil, the first junior company was founded in 1988.

The junior company is a non-profit organization formed and run exclusively by graduate students in schools of higher education. Its main objectives are to complement and to diversify the formation of the students to help them to practice classroom theory.

They serve mainly micro- and small businesses because they have a cost much lower than the market. To guarantee good work results, projects are monitored and supervised by an expert who has knowledge in the area of the project.

The junior companies have great advantages because they have the support of laboratories, technicians and teachers who work with high-quality technology, during the execution of the projects.

Students who have worked in junior companies have an advantage in entrepreneurial practices, management and business skills. Their contact with companies gives them experience in the form of expression and communication.

21.2.5. *Academic mobility*

Academic mobility gives the students a good chance to get new experiences and to acquire new knowledge, not only technically but also culturally. It gives them experience of new realities in their country and in foreign countries without hurting their academic careers.

We can cite two programs that give scholarships to enable students to conduct part of their training in other countries: "E4UM Erasmus Mundus Master in Mechatronic and Micro-Mechatronic Systems" is a two-year program that is conducted in three participant institutions. In the first year, the student selects an institution, does a basic discipline course, a language course and learns about the local culture. In the second year, the student moves to a second institution where he/she attends specialization courses. The three institutions are École National Supérieur de Mécanique et des Microtechniques ENSMM, France; Hochschule Karlsruhe – Technik und Wirtschaft HSKA, Germany and Universidad de Oviedo UNIOVI, Spain (http://www.eu4m.eu). The second program is the "Science without Borders" and it involves interchanging the study programs with many countries; it is sponsored by the Brazilian government. Thus, the program aims not only at the mobility of graduate students, but also at the mobility of researchers and postgraduate students, in addition to the participation of companies (http://www.cienciasemfronteiras.gov.br).

These programs are aimed at training highly qualified personnel, expanding innovative knowledge of industry staff and attracting new talent for research.

21.2.6. *Participation in competition teams*

The participation of students in competitions has been increasingly pervasive in universities, as it consists of the application of technical expertise to leisure activities. In general, teams have a teacher-tutor who coordinates and orients the work, but students are responsible for developing the competition system, projects details, construction/fabrication planning and tests as function of the competition program (with dates previously defined), elaborate technical reports, do oral presentations to defend their project, justify each adopted solution and maintain contact with potential sponsors for financial viability.

Participants in this activity deepen their technical formation and acquire other expertise that is not treated in the course, develop skills such as teamwork, leadership, capacity planning and project management, communication and expression ability, and the capacity to sell ideas and projects.

21.2.7. *Participation in student directories*

The student or academic directory is an association formed by students and aims to defend their interests, to promote rapprochement among students, teachers and faculty administration staff; to develop university spirit within and outside the school, to contribute to the prestige of their institution; to preserve the traditions and integrity of student academic life; to fight for the improvement of democratic institutions, to promote meetings of civic, social, cultural and scientific character, aimed at complementing and improving university education. Additionally, the academic directory aims to support students by involvement in social and technical projects, so that they can have good technical and social formation.

In general, the academic directory tries to give special attention to the new students and to promote greater integration between them and the senior students of the course.

It can be observed that the students involved in academic directories have a political vision much superior to that of the other students.

21.2.8. *Participation and organization of events*

From the work done by students in scientific initiation, in practical activities and in junior companies among others, students can organize events in their area. In such events, business representatives and researchers teach mini-courses that complement the training of students.

This type of organization, which may be local or national, allows them to acquire a great capacity for planning and management, and to develop their communication and expression skills.

In general, this type of organization is established by the initiative of the academic directories and the junior companies.

Participation in events organized by other institutions is a great opportunity which students have to divulge their work, to open space for reflection and discussion of the socio-political context, of their own profession as well as to increase their range of relationships.

21.3. Undergraduate course of Mechatronics Engineering at the Federal University of Uberlândia/Brazil

The undergraduate Mechatronics Engineering course at the Federal University of Uberlândia UFU, Brazil, is a semi-annual course, expected to be completed in 10 semesters having a total workload of 4,170 h. The course began in the first half of 2004 and is under the responsibility of the School of Mechanical Engineering FEMEC (www.mecanica.ufu.br). It should be noted that the School of Mechanical Engineering is responsible for the undergraduate courses in mechanical, mechatronics and aeronautical engineering, in addition to the postgraduate courses (master and doctorate degree) in mechanical engineering.

The participation of the students in practical activities, except in those of the laboratory classes that are obligatory for completion of the curriculum, has been encouraged by the promotion of educational and research scholarships that are obtained by the students through projects submitted to state agencies.

In order to obtain scholarships, teachers have to be dedicated to the course, because they play a fundamental role in applying for scholarships and in the coordination of the students' work.

The coordinator and the collegiate of the course have to do all the monitoring and execution of the study program during each semester and accompany the participation of the students in their various activities.

The following are comments on the implementation of practical activities in mechatronics engineering. The next section will give a general evaluation of the course that has been functioning for eight years.

21.3.1. *Practices activities of laboratory*

To prepare the political-pedagogical project of the mechatronics engineering course, we tried to obtain a significant number of laboratory practical classes, always associated with theoretical classes; this resulted in about 20% of the total workload of the course.

Because of the characteristics of the course and its teachers, some practice classes are taught in specific didactic laboratories and others in research laboratories.

In order to optimize staff support and the use of the physical space, the same location is used by more than one discipline. In this case, correct planning must be done in order to have a schedule that suits both the teachers and the students.

The specific didactic laboratories, in general, are related to the basic disciplines such as physics and electronics, and almost all of these use commercial components and have the support of the technical staff to organize the infrastructure for classes.

In the practical classes taught in research laboratories, the number of students allowed to participate depends on the space available and on the quantity of equipment to be used simultaneously. In these cases, the teacher plans his/her class and divides the students into groups so that they can participate in all the planned activities.

In most laboratory classes, there is a maximum of 12 students. This facilitates the teacher’s work and allows the students to participate effectively in practical activities.

Figure 21.2 presents an experimental bench used in the practical classes of basic and power electronics. In this laboratory work, six students are present in each group. Figure 21.3 shows the bench for the practical activities of hydraulic and pneumatic controls and industrial automation using industrial communication networks.

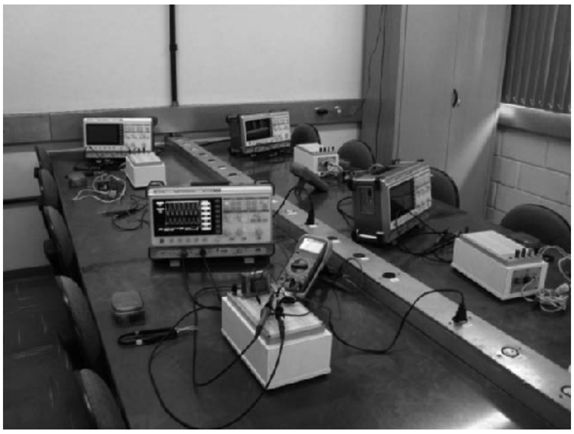

Figure 21.2. *Photo of didactic laboratory for activities on basic and power electronics*

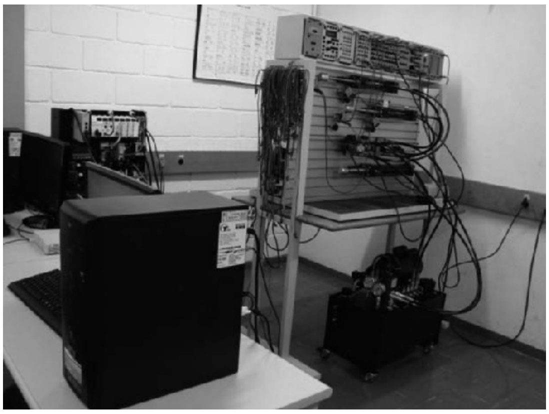

Figure 21.3. *Photo of didactic laboratory for activities on hydraulic and pneumatic command systems, and industrial automation*

21.3.2. *Monitoring*

The Federal University of Uberlândia has a monitoring program with and without scholarships. The monitor contract is for six months and at its end, the student has to submit a report of his/her activities.

Mechatronics engineering students, in general, participate in the first periods of the monitoring program in which there is a strong focus on the disciplines of mathematics (differential and integral calculus, analytical geometry and linear algebra). This can be explained, at least partly, because in the later periods the students give preference to other activities related to their specific training.

21.3.3. *Research initiation activities*

Mechatronics engineering students (with or without scholarships) at the Federal University of Uberlândia have a strong participation in scientific initiation activities. Most scholarships are paid by development agencies and private companies.

Students participate in scientific initiation activities from the earliest periods of the course. Although the number of students varies, more than one-third are usually involved in it.

Figure 21.4 shows a student working in the Robotic and Automation Laboratory for controlling a tridimensional digitizer within a scientific initiation program.

Figure 21.4. *Student activities in a scientific initiation program*

Again teachers play an important role because they coordinate activities and seek scholarships for the students. Coordinators of the course always try to show the students the importance of participating in this type of activity, which regularly has lectures by professors and scholarship students. This type of activity has been a reference for students even after graduation because research depends on the initiative necessary to solve problems and to learn this in an autodidactic manner.

21.3.4. *Participation in Junior Companies*

The META junior company of the School of Mechanical Engineering FEMEC (http://www.meta.mecanica.ufu.br/) was founded in 1992 and is one of the most reputable junior companies at UFU. In the 20 years of its existence, META has developed various projects, mainly in the development and improvement of products and processes, serving small, medium and big businesses.

The META junior company has been active in Junior Brazil, the Brazilian Confederation of Junior Enterprises, which represents junior companies nationwide and develops the Junior Enterprise Movement as an agent of business education and of new business generation (http:// www.brasiljunior.org.br).

21.3.5. *Academic mobility*

Academic mobility can exist between the federal institutions of higher education in Brazil, or between foreign educational institutions that have agreements with the UFU.

The Federal University of Uberlândia has a long history of international scientific-technical cooperation, which began in 1987 with the *Institut National des Sciences Appliquées de Lyon INSA Lyon*, France, through an exchange agreement between Brazilian and French undergraduate students in mechanical engineering.

In recent years, the Federal University of Uberlândia has greatly increased scientific-technical cooperation with foreign institutions. Today, the University has 85 bilateral agreements with international institutions. Seven of these offer double degrees. The majority of these agreements, 55, are with Europe. Of these 55 agreements, 30 are with France.

Currently, with the incentive of the Brazilian government through its program “Science without Borders”, new opportunities have opened up, and countries that did not previously have a tradition of exchange programs with Brazil began offering opportunities for the exchange of undergraduate students. With these new opportunities, many students will have a chance to participate in exchange programs, to acquire knowledge and especially to have experience of other cultures, thus enriching their professional formation, which is essential in a globalized world.

To apply for scholarships in the international mobility programs, students must have a good academic performance and generally have participated in extracurricular activities such as scientific initiation and monitoring, and have experience in competition teams, etc.

From 2007 until the end of 2010, 30 mechatronics engineering students have participated in international mobility. In 2011, six students returned for the second half of the 2012 semester, and 17 left Brazil to participate in international mobility. This increase in participation is related to the availability of scholarships through the “Science without Borders” program, and the number of mechatronic students participating in the program is very expressive when compared to that of the other courses at the Federal University of Uberlândia.

21.3.6. *Participation in competition teams*

Participation in competitions is a form of entertainment combined with the application of technical and scientific knowledge. Besides this, the students learn by active participation in the event, because many of them have not attended the necessary specific disciplines required by the specific activity.

Students are introduced to this type of activity from the first period of the “Introduction to Mechatronics Engineering Course”, where they are divided into groups of three or four students. These groups have to develop a simple engineering project for a competition at the end of the semester. To develop this system, students must use basic course content, studied throughout the semester, or knowledge acquired even before entering the University. Besides the competition, each team has to write a report on the project, and justify the adopted solution with a subsequent oral presentation.

During the course, the organized teams focused on the competition are described as follows: (1) the Tucano Aero Design Team (http://www.mecanica.ufu.br/node/193), which aims to develop prototypes for model aircraft competition at SAE Brazil Aero Design (http://www.saebrasil.org.br/eventos/programas_estudantis). As per the rules of the competition, projects are judged according to several criteria: preparation of reports, technical drawings, an oral presentation of the project, maximum weight to be transported during test flights and accuracy in predicting the maximum transportable weight. (2) the Mini-Baja Cerrado Team, established in 1998, aims at the development and construction of recreational vehicles with four wheels. One of these participates annually in a competition sponsored by SAE Brazil. The following are evaluated in each competition: project reports, cost of mass production, safety aspects, operating comfort, traction capacity, steep ramp capacity, acceleration, top speed, braking, maneuverability and durability. (3) The EDROM Team for the Development of Mobile Robotics aims to participate in competitions involving the development of mechatronic systems geared toward mobile robotics. The team has participated in national competitions and in the South American Cup in Humanoid Robot categories (http://www.robocup.org) and SEK IEEE Standard Educational Kits (http://www.cbr2011.org/sek.htm) and (http://ewh.ieee.org/reg/9/robotica). Figure 21.5 shows the EDROM students in their workplace.

Figure 21.5. *The workplace of the EDROM students*

The teachers responsible for orientating and coordinating the work have a decisive role in the success of the teams.

21.3.7. *Participation in student directories*

The participation of students in the academic directories at UFU is much more associated with the political aspect than with the technical training. Students who take part in the academic directories have the opportunity to participate in the higher councils of the University, and to participate in philosophical discussions about engineering and about their educational institution. These discussions also take into account the relationships and influences that students have on society. All this is extremely enriching for the formation of responsible citizens.

The mechatronics engineering course has its own student directory with a vision more focused on the quality of the course and on the formation of students.

21.3.8. *Participation and organization of events*

The students can participate and organize scientific and/or academic events. For example, each year the students of mechatronic, mechanical and aeronautical engineering organize a scientific-technical event called the Week of Mechanical, Mechatronic and Aeronautical Engineering (SEMEC) that has celebrated its 14th annual event in 2012, which includes seminars, short courses, technical presentations of works by undergraduate and postgraduate students. The target audience is the academic community, businesses professionals in the city and in the region, teachers and engineering technicians in general.

21.3.9. *Other activities*

In addition to the activities listed above, students can participate in a special program, created and funded by the Ministry of Education in 1979, called the Tutorial Education Program (PET). PET groups are formed of 12 students, guided by a tutor who is responsible for the orientation, coordination and good performance of the group.

The following are some PET characteristics: ample interdisciplinary academic formation, collective action, continuous interaction, and planning and the executing of a diverse program of cultural and scientific activities.

The PET program at the Faculty of Mechanical Engineering (PETMEC) was established in 1992 and has actively participated in the formation of professionals in engineering.

21.4. Discussions

The accumulation of theoretical content at the beginning of engineering courses discourages the students, and has, as a consequence, the abandonment of the course by the students in the first years. When the students have the opportunity to get involved with extracurricular practical activities early in the course, they get motivated and acquire an overview regarding the application of the theoretical content, and this helps them to overcome the difficulties encountered in the first semesters.

The students who get involved with practical activities have experience of real problems before they see the theory referring to them, and this stimulates their interest in the theoretical content, because they can see the application of theory when it is taught in the classroom.

The globalized world requires a great versatility in engineering professionals and, in this case, multidisciplinary courses such as mechatronics engineering require that young engineers have a much broader view of systems, and also know how to tackle practical problems. The practical activities during the course make the mechatronic engineer distinctive professionals. Because of the large field of performance, mechatronics engineering students can get involved in all the extracurricular activities offered at the Federal University of Uberlândia, so they can start their practical activities in the first periods of the course.

Biannual meetings of the course collegiate encourage the students to participate in extracurricular activities from the beginning of the course. Graduated students are also invited to present their vision of the educational process that they experienced during the course.

All the extracurricular activities in which students participate can be integrated in the curriculum, and have a value equivalent to 90 h in the mechatronics engineering course at the Federal University of Uberlândia.

The importance of the commitment of teachers in the process of professional formation should be stressed. This is because it is teachers who look for scholarships, coordinate research and service projects and competition teams. For this reason, it is necessary that teachers be motivated and be aware of their importance for the course and student formation.

The collegiate of the course undertakes semi-annual monitoring of the academic performance of mechatronics engineering students. From these analyzes, it has been possible to identify potential adjustments in the curriculum in order to achieve greater efficiency in learning.

Early in the course, some disciplines had laboratory activities as a complement to the teaching activities. However, it can be verified from other disciplines with laboratory activities, in which students participate effectively in practical activities, that increasing the laboratory workload could improve the quality of learning and thus academic student performance.

The following tables present statistical data since the beginning of the course in mechatronics engineering at the Federal University of Uberlândia. Table 21.1. shows examples of the approval rating of disciplines that have practical classes with effective participation of students in all of the planned activities, and Table 21.2 shows the approval rating for some disciplines that have no practical classes. From the analysis, it was possible to include some practical classes to enable effective participation of students in laboratory activities. No statistical data are shown because the changes were implemented only for two semesters. It is worth mentioning that we recall effective participation of students in laboratory activities in which the student develops the system proposed by the teacher. In this case, the teacher acts as a supervisor of the realized work.

Discipline	Approval rating (%)
Applied programming to engineering	91.1
Computer-aided design	93.1
Industrial automation	95.7
Industrial network	94.7
Pneumatic and hydraulic command systems	93.3

Table 21.1. *Approval rating in disciplines with effective participation of students in laboratory activities*

Discipline	Approval rating (%)
Digital control of systems	64.7
Digital electronics	81.7
Electrical circuits for mechatronic	75.2
Kinematics	74.9
Numerical calculation	77.1
Principle of materials science	74.6
Thermodynamics	73.8

Table 21.2. *Approval rating of students in disciplines without laboratory activities*

Another important aspect to be noted is that all students who received scholarship for international mobility, a total of 104, since the beginning of the course, have already participated in practical activities (sections 21.3.2–21.3.9), beyond the activities of compulsory disciplines. In 2012, from 274 students on the course, 25 students went abroad through the international mobility program.

In terms of incentives for students to participate in extracurricular activities and of their monitoring by the collegiate of the course, what can be seen from the beginning of the undergraduate mechatronics engineering course at the Federal University of Uberlândia is that dropout is small, the students are very well qualified and get good professional placements.

21.5. Conclusions

Encouraging the participation of students in extracurricular practice activities in the early periods is of a fundamental importance for mechatronics engineering students. This type of participation gives the students a vision of where theory can be applied. Thus, the students have a share in the construction and contextualization of the theory given in the classroom.

The involvement of students in extracurricular activities such as research initiation activities, PET, Mini-Baja, EDROM, and Aero Design, makes them feel more motivated, and able to see and experience real engineering problems in a safe manner.

Lack of student motivation is one of the most important reasons for the high number of dropouts from engineering courses, and involvement from the beginning of the course in practical activities can reduce this number in the early periods of the course.

This process of encouragement and participation in extracurricular practical activities needs the decisive participation of teachers, because it is they who coordinate all the activities, from the obtaining of scholarships to the formation of the young engineers.

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