

Problems of organizing dual education for training engineers in the field of mechanical engineering

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Abstract. The article analyzes the conditions for the effective application of the principles of dual education in the training of engineers in mechanical engineering specialties. An example of experimental implementation of the method with high results is given.

INTRODUCTION

In recent years, in the Republic of Uzbekistan, along with the high rates of development of the national economy as a whole, there has also been an increase in the number of industrial enterprises and the pace of their technological advancement. This is mainly due to the establishment of production facilities based on the import of modern foreign technological complexes. Accordingly, qualified personnel are required for the operation and maintenance of such complexes. However, in order to achieve technological sovereignty and bring the country closer to the ranks of technologically advanced states, it is necessary to train specialists capable not only of operating and maintaining but also of reproducing new models of modern technological equipment. In this regard, there is a need to develop an organizational model for training highly qualified engineering personnel for the mechanical engineering industry based on modern, highly efficient methods.

Modern metalworking production is a comprehensive system that includes a wide range of production strategies (doctrines), computer programs, technologies, machinery and tools, as well as methods of quality control, personnel training, and labor standardization. It represents an entire set of actions and various measures aimed at achieving competitive production, the main objective of which is to introduce new products to the market in the shortest possible time and at minimal cost. The key principle of modern manufacturing—often referred to as “smart” or intelligent production - is its flexibility, that is, the ability to create new competitive products.

In the era of globalization, one of the major challenges facing the metalworking industry worldwide is the shortage of highly qualified personnel capable of operating modern, highly automated equipment.

The authors of several studies believe that the shortage of specialists in metalworking industries will continue worldwide; moreover, the deficit of qualified personnel will only increase. This will occur primarily because the complexity of technological equipment and the complexity of the parts being processed are growing. Work on modern equipment is impossible without the use of computers equipped with specialized mathematical software. This increases the requirements for maintenance personnel, who must not only be able to select machining modes and develop processing technologies, but also be able to generate programs and make adjustments to previously created ones. In addition, a specialist must understand the fundamentals of the machine's electromechanics and electronics. The complexity of modern machine tools can lead to situations that are not addressed by any existing instructions. Thus, modern equipment imposes high demands not only on the intellectual abilities of maintenance personnel, but also on their personal qualities — that is, a person must be capable of making correct decisions in non-standard situations

MATERIALS AND METHODS

At present, amid an acute shortage of such specialists in the republic, discussions are being held on the introduction of dual education principles into the system of training qualified engineers. These principles have proven their effectiveness in a number of Western countries [1].

As noted in publication, at present three main types of dual vocational education systems have been established in global professional training practice:

1. Market-oriented system.

This type of system is practiced mainly in the USA, the United Kingdom, and Japan. It represents workplace-based training that is not regulated by state legislation.

2. Education-institution-oriented system.

This model is applied in Italy and France. The educational process takes place entirely within the educational institution without the participation of enterprises. Students acquire professional skills in public educational institutions. The duration of study ranges from three to five years. Practical training also takes place within the educational institution.

3. The third system is a combination of vocational and theoretical education.

4. This system is practiced in Germany, Austria, and Switzerland, with the German dual education system being recognized as the best in the world. The main concept is the division of training into a practical (industrial) part and a theoretical or vocational-theoretical part.

The authors of this publication consider the third dual system to be the most reliable and viable model for training engineering personnel, as it fully meets the requirements of all parties interested in professional training — the state, employers, and students.

The advantages of the German system are also highlighted in work [2]. The practice of training high-level personnel for CNC machine operation in Germany consists of several stages.

The first stage involves the preparation of specialists in technical universities (specialist degree). The second stage includes training specialists in a corporate university established and funded by leading German machine-tool manufacturers. During the two years of study in the corporate university, young specialists are trained and the qualifications of workers, technicians, and engineers operating advanced technological equipment are upgraded.

The third stage of training consists of working on a CNC machine as an apprentice under the supervision of an experienced master. This stage may last up to one year (the total duration of training for modern CNC operation is $4 + 2 + 1 = 7$ years). We are referring to specialists capable of operating the latest CNC machines and organizing high-tech automated production lines that require competencies in generating CNC programs using CAM systems for machining parts, organizing remote access for technical support and service operations (such as remote diagnostics and repair of machines by the manufacturer), monitoring machine performance parameters, and more.

Although such discussions have been ongoing for quite some time and several government acts have been adopted to implement the principles of dual education in the universities of the republic, there are still very few real examples of their full-scale application. It is evident that this issue requires deeper analysis.

If we try to understand the difficulties in implementing dual education, it is first necessary to determine which elements its effectiveness is based on. A simple analysis reveals the distinguishing features of this system compared to the traditional one. At the same time, the main requirements for the effective application of the dual education method can be formulated as follows:

1. Organization of the educational process directly at the production enterprise;
2. Correspondence and completeness of the types of production processes implemented at the enterprise to the direction of students' training;
3. Direct participation of students in production process areas requiring engineering solutions;
4. Availability of highly qualified and experienced teaching staff in educational and production positions;
5. Preparedness of conditions at educational and production sites for conducting the learning process for a certain number of students;
6. Possibility of organizing the educational process under production conditions based on the principles of induction and deduction (which is rarely found in real enterprises).

As specialists may note, the number of enterprises capable of meeting such requirements, especially in the field of mechanical engineering, is very small in the republic, and this is one of the main obstacles to the effective implementation of dual education.

If we speak about engineers of the highest qualification, as noted above, they are currently in short supply not only in Uzbekistan but also in countries with advanced technological development. At the same time, it should be emphasized that although the required number of such specialists is relatively small even in these developed countries, it is nevertheless sufficient to generate new ideas, to unite lower-level specialists around them, and to lead the technological strategy of a cutting-edge enterprise. That is, the entire engineering staff can be conditionally divided into an avant-garde group of idea generators of high qualification and small numbers, and a group of technical executors of medium and lower qualification, who make up the main mass of engineering personnel.

For example, back in the mid-1980s, during a visit by a high-level Soviet delegation to the Japanese company *Fanuc*, they were surprised to discover that the entire technical and innovation policy of the famous company was carried out by a group of young, uninhibited specialists numbering no more than 5 or 6 people. However, according to one of the members of that delegation, all the necessary conditions demanded by these firms are immediately created on their part.

Based on the above, our idea consists, firstly, in the fact that a small avant-garde group of engineers can be trained in separate groups according to advanced programs within the general stream of students in a given field. To reduce economic costs, the rest of the stream continues their studies according to general programs.

In our view, this approach does not cause any negative sociological consequences. Based on direct observation of the results of higher engineering education over the past 50 years, we can present an expert assessment regarding the Republic of Uzbekistan, without claiming high accuracy.

It is not difficult to notice that over time, students' attitudes toward the educational process have undergone a certain degradation. Discussions with a number of foreign experts on this issue show that such processes are observed not only in Uzbekistan but also in many countries around the world. Perhaps one of the main reasons for this is the unprecedented increase in the flow of information, which is now received not in traditional written or printed form, but in a much more accessible electronic format [3].

From this point of view, the history of the educational process can be divided into pre-electronic and electronic-information periods, the boundary between which can be roughly placed at the beginning of the current century. During the earlier period, the proportion of specialists who managed to achieve high qualifications in the absence of mobile communication, the Internet, and other technologies, according to our estimates, was about 30 percent. At present, however, the share of such specialists does not exceed 15 percent among graduates of engineering universities. If such a ratio did not previously cause significant discomfort for industrial enterprises, the current ratio highlights the shortage of highly qualified specialists and seriously slows down scientific and technological progress. Therefore, the solution to this problem lies in restoring the above-mentioned ratio to previous levels, as well as in increasing the quality of education and the number of graduates belonging to the avant-garde group.

Secondly, a comparison of the learning conditions within the walls of a university with those at an enterprise at first glance shows their complete inconsistency. However, in our opinion, this inconsistency can be overcome under modern conditions. Analysis shows that, in the current environment, the distinctive features of dual education listed above with efficiency even higher than that of an operating enterprise that can be modeled directly within the university itself. In particular, requirement No. 6, which is difficult to fulfill under real production conditions due to possible disruptions in the technological rhythm, can easily be implemented in a laboratory setting.

The basis for such conclusions lies in the fact that the republic currently has the material capacity to equip universities with modern technological equipment and instruments. The process of equipping universities is already underway; however, this alone is not sufficient for organizing training on the principles of dual education. To ensure the effectiveness of the process, it is necessary to implement all of the above-mentioned requirements of dual education [4].

If we assume that the issues of equipping universities with machines and instruments are generally resolved, then to meet the necessary requirements for dual education, it will be necessary to organize a university laboratory for small-scale production of parts and assemblies.

At the same time, small-scale production provides students with the opportunity to learn various technologies (preparatory, mechanical processing, assembly) for different types of parts. Moreover, this form of production organization exists in many domestic enterprises, and it is precisely at such enterprises that the advantages of modern CNC (computer numerical control) machines are best manifested. These enterprises, with a high probability, will be the main customers of engineers from the avant-garde group. Considering also that small-scale production is sufficiently profitable, it is easiest to organize it within a university laboratory.

Profitability, in this case, is of great importance, since when organizing production within a university, the same technological preparation of production processes is required as in any enterprise. This entails significant and

unavoidable expenses for the university's budget organization, associated with the acquisition and maintenance of tools, devices, consumables, auxiliary materials, and additional staff.

Therefore, when organizing dual education within the university itself, another important requirement arises that the need to create a training and production unit within its structure, based on financial independence. Without financial autonomy, the existence of such a unit would be very problematic, since the high-intensity financial system of the university would not be able to ensure the continuous and reliable progress of both educational and production processes in the organized training environment

RESULTS

In conclusion, we would like to note that we have some experience in the experimental organization of dual education on the territory of the Fergana Mechanical Plant, dating back to the mid-1980s. About 60 students majoring in *Mechanical Engineering Technology* (2nd and 3rd year) participated in the experiment. They studied 2 days a week at the university and 4 days in the plant's programming and control department.

The training program was developed by the university in collaboration with leading representatives of the plant. It primarily took into account the enterprise's current requirements for the competencies of future specialists, as well as the conditions for training students directly on the factory premises, including opportunities for maximum integration of students into ongoing technological processes. The foundation of the program was, of course, the state curriculum established for this field of higher education. However, at the request of the enterprise, it was supplemented with several additional subjects that, in their opinion, were necessary for developing the competencies required at the plant. The instruction of most of these subjects was entrusted to the enterprise's own specialists.

The results of the experiment exceeded our expectations, as after one year of such training, the plant's management expressed a strong desire to immediately employ all the students as full-time engineers upon the issuance of their higher education diplomas which, of course, was not yet possible at that stage.

CONCLUSIONS

We believe that the reasons for such results lie in the fulfillment of almost all the requirements of dual education described above. That is, the plant had at its disposal the most advanced equipment and technologies of the time, highly professional engineer-mentors, and individual workplaces for engineers. Students took direct part in the production processes of the most advanced aircraft that is not as workers, but as engineers.

Since the recreation of such unique conditions is currently not possible, preparatory work is being carried out to organize dual education in the laboratory complex of Urgench state university according to the type we propose.

The laboratory complex is equipped with technological equipment that allows the implementation of various technologies for manufacturing complex parts and assembling machines, a significant portion of which is equipped with CNC systems. Conditions are also available for organizing foundry processes and performing complex measurement operations using modern measuring instruments.

To carry out the full cycle of design and technological work, a dedicated room has been established, equipped with high-performance computer hardware and the necessary software.

To meet the above requirement — ensuring student participation in an active technological process — partnerships have been established with local enterprises to provide the laboratory with real production orders for manufacturing small batches of parts [5].

The financial aspects of such commercial activities are handled within the technopark, which operates, as intended, as an independent structural unit of the university based on financial self-sufficiency.

As can be seen, in this case we are able to meet all the requirements for organizing dual education that were formulated above. At present, this training process has been launched experimentally for a small group of master's students. In the future, it is planned to implement it in stages: first for small groups of bachelor students selected from among the most capable and motivated members of academic groups, and later within the framework of courses for training highly qualified CNC machine operators, the organization of which is planned on a commercial basis.

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