Experience of international collaboration in preparation of masters in “Mechatronics” with call for funds from Tempus and Erasmus programs

V A Zhmud\(^1\), G A Frantsuzova\(^1\), L V Dimitrov\(^2\), J Nosek\(^3\)

\(^1\)Novosibirsk State Technical University, 20, Karla Marksa Ave., Novosibirsk, 630073, Russia
\(^2\)Technical University of Sofia, Sofia, 8, Kliment Ohridski Boulevard, Bulgaria, 1756
\(^3\)Czech Technical University, Liberec, Studentska 1402/2 461 17 Liberec 1, Czech Republic

E-mail: zhmud@corp.nstu.ru

Abstract. This paper reveals the main problems of creating and implementing double diploma programs between universities of Russia and Europe. Novosibirsk State Technical University implements such programs with Technical Universities of Sofia (Bulgaria) and Liberec (Czech Republic). The paper presents the latest results of this activity and discusses the possibilities of its development in the field of joint postgraduate training, as well as joint scientific research with the involvement of students and postgraduate.

1. Introduction

The modern university is not able to develop in isolation without carrying out joint programs for the training of students and PhD students. Naturally, the desire for such partnership proceeds not only from the administration of the university, but also from the top management of the departments and faculties, as well as the teaching staff. Activity on the part of students without proper involvement on the part of teachers, unfortunately, is almost not observed. Only in exceptional cases, students apply for help to teachers with the request to promote their mobility, including a foreign one. Most often the opposite happens: the teachers notify the students about the available opportunity to carry out training at a foreign university without dismissal from the university where the training is currently taking place. An absolute unexpectedness for students is the possibility of receiving payment for such trips. But even so, not every student shows personal interest in such trip. The major reasons are social factors, the established scale of values and motivations, personal characteristics of temperament, family circumstances, etc.

Teachers, on the other hand, do not need to participate actively in the preparation and implementation of such mobility if they themselves show no interest in these activities. Especially in case if a sufficient number of students, suitable for the implementation of specific acts of mobility, meeting requirements for candidates and being interested in similar travels for the proposed periods of time, are not sought for among other students.

In this case, the main problems are, first, the insufficient awareness of students, their parents, and sometimes even the faculty of universities, and second, an extremely low level of knowledge of the
English language among the majority of students of Russian universities. Third, there is low self-esteem and the influence of lack of faith in success when submitting projects to the competition on the result.

This paper fills in a certain gap in the awareness of the above-mentioned issues on the part of students and faculty.

2. The Concept of the Program of Double Diplomas

It would be more correct to call the program of double diplomas as a program of two diplomas received simultaneously [1–3]. Indeed, the question under discussion does not concern any special diplomas, for example, written in two languages at once and issued on behalf of two different universities. The point is that the student in one university is sent for a substantial time period to another university without deduction from the basic university. At the same time, the training programs in two universities with the efforts of the initiative groups from both universities are coordinated and synchronized so well that there is such an option for their implementation which, firstly, meets all the requirements of each of the two state standards, bound on partner universities. Secondly, students can pass successfully exams for one standard period of study, consisting of two parts, each of which is implemented in different universities. At the same time, both universities recognize that the preparation at a partner university is appropriate for their own requirements and accept all the grades of examinations and grades of the student's knowledge as legitimate.

Let us analyze these bases by the example of the joint educational program (JEP) on the master's degree [1–2].

The ideal option is obtained when the terms of taking the master course of two universities coincide.

In this case, the student is enrolled for half the term at one’s domestic university; the second half of the term is spent at a foreign university, after which one takes one’s degree at the foreign university, receiving a diploma from this university on this basis. Then the student returns to one’s domestic university, does the same work in one’s native language and receives the diploma of this university.

The problems that arise in the implementation of such JEP are noted in the authors’ publications on this topic [1–3]. First of all, there is a discrepancy between the programs of two partner universities. The same publications analyse how these problems can be overcome and how they are actually overcome by the example of a dual master program implemented jointly by Novosibirsk State Technical University (Novosibirsk, Russia) and Liberec Technical University (Liberec, Czech Republic).

A mandatory condition for the implementation of JEP is the state accreditation of the educational program in both universities, which is desirable for international accreditation, but this process has not been yet developed well in the territory of the Russian Federation.

One of the most significant problems is the financial problem. The question arises concerning who is going to pay the costs of students’ moving or flying to another country, as well as the costs of issuing a visa (which may also require a visit to the capital), and additional costs for living abroad.

The long experience of implementing the JEP shows that the amount of 2000 Euros is sufficient to pay off additional costs. Of course, a student cannot live for ten months on this money, and even pay for it from all compulsory transportation costs. But if a student does not participate in the JEP, he still spends money on life and food. Therefore, in this case, it may be a question of compensating only the difference in the expenses for a specified period, and in this case the indicated amount is sufficient. In addition, the student may have the opportunity to receive funds from his parents or other relatives (sponsors), and he can have his own sources of income or savings if he previously worked or has earnings. Nevertheless, it is not advisable to focus on these additional sources, since in this case the opportunities for students to participate in JEP are determined not by his personal achievements in studies, his motivation, talent and efficiency, but by completely different qualities that do not directly relate to his value as a student and a future specialist.

Let us consider the components of the student's motivation in participating in the JEP.
1. The student should be oriented not only to training, but also to scientific research, as well as to further professional activities.

2. The student should be sufficiently informed about his own university and the opportunities for further education if he does not participate in the JEP.

3. The student must have a fairly good idea of the university in which he intends to study. He must know the advantages that education gives him at this university, at the chosen faculty and the direction of training. These factors include:
   a) an additional tool base (laboratory equipment), which allows one not only to obtain the best skills in the future specialty, but also to carry out such studies that are difficult to carry out at one’s domestic university;
   b) the information about the prospective supervisor and the topic of the proposed thesis work, information on the success of the obtaining degrees and the usefulness of the theses under the supervision of this supervisor;
   c) the information on additional opportunities for further study and (or) further employment in case of participation in the JEP at this university;
   d) the information on possible additional scientific contacts and interest in them.

4. The student must understand the difference between the diplomas obtained in each of the universities: if the second diploma provides nothing in terms of prospects for further professional growth, there is no reason to receive it. The situation is symmetrical: if the diploma of the domestic university is inferior in all respects, and, therefore, does not add any opportunities for professional growth, the student can find it senseless to receive it after receiving the diploma at the second place of study.

5. It is desirable that the host country should be attractive for the student, allowing one to realize tourist needs and (or) the need of familiarization with the culture of this country. For this reason, it is often impossible to ensure an equal exchange; students from one state are more willing to go to another state, whereas reverse mobility is not so attractive.

The motivation of the sending party, as well as the motivation of the receiving party, consists of the following factors:
1. The possibility of encouraging the administration for international activities.
2. The possibility of involvement in international research by establishing contacts and strengthening them.
3. The possibility of personal mobility in the framework of the enlarged program.
4. The possibility to exchange with advanced learning technologies.
5. The possibility of joint publications.
6. The possibility to participate in joint projects and increase the likelihood of their support.
7. The possibility of increasing the list of successful students.
8. Creation and development of prerequisites for the implementation of a foreign language training program in order to develop opportunities for financial support in the future.
9. Direct and immediate financial interest (if the program is implemented within the framework of a project that received financial support).

Ensuring the success of such program is seen in the organization of at least a minimum competitive selection of applicants. If there is no competition for training, everyone is sent, but not everyone can meet all the requirements and successfully complete the JEP training. In addition, unforeseen circumstances can often arise, such as changing the marital status, which can lead to the refusal to participate in the JEP after sending and receiving parties have done enough to implement it.

Therefore, reserve candidates are necessary, which means that the competition should not end ahead of time. Even if students require additional language training to participate in the JEP, and even if this training is organized using the funds of the sending university, at this stage the candidates should not be eliminated. On the contrary, it is desirable to involve as many students as possible in the process of improving the skills of mastering a foreign language; at least it is desirable to have a reserve
at the level of 50-100%. In this case, it is advisable to make the final choice of the best students immediately before the "irrevocable" actions for sending them abroad for training.

3. **Peculiarities of Joint Educational Programs for Bachelor, Master, Post-graduate**

The experience of JEP implementation shows that they are very laborious and expedient for different levels of education.

The levels of education imply existing levels of higher education:

1. Bachelor degree comprises 4 academic years (8 semesters). This education is given to people who have a secondary education and win successfully the competition on the basis of a unified state examination (USE) or passed the entrance examinations to the university and scored the required number of points. Persons who do not win the competition can be trained on a commercial basis (under the contract).

2. To become a specialist, one needs 5 or 5.5 academic years of training (10 or 11 semesters). This education is provided under the same conditions as those of the bachelor's degree, but takes longer and, correspondingly, is more voluminous owing to the features of the trained specialty. It is also possible to train at the expense of the budget or on a contract basis.

3. Master’s degree takes 2 academic years (4 semesters). This education is provided for persons who have successfully completed a bachelor's degree or a specialty and passed the entrance tests. With a limited number of places, competitive selection is carried out. Persons who do not win the competition can be trained on a commercial basis (under the contract).

4. Postgraduate course (PhD students) includes 4 academic years. This education is provided for persons who have successfully completed a master's degree or a specialty and successfully passed the entrance examinations. With a limited number of places, competition takes place. Persons who do not win the competition can be trained on a commercial basis (under the contract). Also, universities can form a target set, for example, to train future teachers for this university or at the request of enterprises.

The implementation of JEP for bachelors or specialists is extremely difficult and not justified. Synchronization of the curriculum containing 8 or more semesters is practically impossible, and the expediency of obtaining two bachelor's degrees is questionable.

Master’s program is the most flexible level of education, the presence of only four semesters greatly simplifies the tasks of synchronizing the curriculum. Often the last two semesters of the Master’s program contain a small number of disciplines, studied in the form of lectures, laboratory works or seminars. Most of the disciplines are studied in the form of research practice, research work, which further simplifies the synchronization of curricula.

With regard to postgraduate studies, there is now a significant discrepancy in terms of study, namely: full-time post-graduate education in Russia is four years, whereas PhD education in all European countries assumes a three-year course.

In addition, the characteristic difference between postgraduate studies is the fact that the diploma issued after graduation is not as important as the diploma obtained in the case of a successful presentation of a thesis.

Currently, these are different diplomas; the value of the former in the presence of the second is questionable. There is no direct prohibition on the presentation of the thesis before presenting the final qualification work at graduate school. Thus, it turns out that if a graduate student presents successfully a thesis and receives PhD, his motivation for further postgraduate studies disappears.

Obviously, in this case there are some flaws in the standard. If one introduces a ban on presenting a thesis before the completion of the postgraduate study, this would contradict to the position of Higher Attestation Committee (HAC), which at present not only does not require completion of postgraduate studies, but does not require such training at all. Now the PhD thesis can be presented by a person who has taken a bachelor's degree or a specialty, provided that all qualifying examinations for the PhD degree are successfully passed. Thus, it turns out that the postgraduate course is, firstly, a way to help a PhD student to acquire the necessary knowledge to pass qualifying examinations. Secondly, it allows
completing formally all procedures, relating to admission to the examination, its passing and receiving documents confirming the passing of this examination. Thirdly, there is a way to promote scientific research performed by the trainees. Fourthly, it includes the method of acquiring additional knowledge, skills and abilities demanded according to the specialty. Fifthly, obtaining an extract from the institution where a student studies that the training meets the requirements of the HAC and the work can be submitted to the dissertation council. Sixthly, it is the way of obtaining the document on the successful completion of postgraduate study. In addition, for the entire period of study, a PhD student receives a scholarship provided by the budget.

A PhD student can limit himself to using postgraduate study only for the first two tasks, namely, to prepare for the candidate examinations and for their passing. After that, he may refuse from all the procedures related to postgraduate study if he make a decision on whether one wants to perform research or obtain a document at the place of study in addition to the above-mentioned organized scheme. Thus, the student can shorten the path to obtain the degree of PhD of science.

Finally, it is obvious that at the final stage of training, i.e. during the fourth year, the PhD student faces two tasks: presenting graduation qualification work (GQW) in PhD studies and presenting a PhD thesis. If PhD student is not ready to defend GQW, he is to be expelled from the PhD training, which in no way hinders the subsequent presentation of the thesis after completion the study. If the graduate student is ready to present the thesis, he can also drop out of the graduate school and deal only with the actual presentation of the thesis without spending time and efforts to present GQW. One sees that the PhD-student is not sufficiently motivated; at that, he, having a practically completed thesis, nevertheless spends a significant part of his time defending the notorious GQW. This defence, of course, can be quite good "training" for the future presentation of the thesis, but if the thesis is ready in its entirety, there is no more expediency in concentrating attention precisely on working with the dissertation council? And if the thesis is at least partially unprepared, the graduate student, if he understands the situation perfectly, should fairly critically evaluate his work and not expose it as GQW, and, instead of trying to defend the GQW, use his time to complete the research and thus to shorten the path to successful presentation of the PhD thesis.

The aspects of postgraduate study in accordance with the new examined standards inevitably affect the possibilities of implementing a joint educational program for PhD study.

If the PhD-student has the opportunity to simultaneously study in two PhD courses, in Russia and in Europe, does this mean that the trainee should receive two diplomas when graduating from the graduate school?

In this case, there is no analogy with the master's degree.

Indeed, at the end of the Master's Degree a diploma is given according the received education, no further actions, such as presenting a thesis outside an educational institution, result in a more significant diploma for the same period of study, which is important.

PhD study, above all, is aimed specifically at further actions to protect the results obtained during this period of study in an external organization, in the dissertation council. If a diploma on successful completion of the graduate school is not required for such presentation, then it is unnecessary for anyone who is focused on presentation. Such diploma can only be useful to those who are not attuned to presenting a thesis and want to receive at least some document that indicates that one's qualification is higher than the qualification of the graduate of the Master study, confirming the fact that additional higher education is obtained in graduate school and replaces the diploma of PhD of Science.

If, based on the results of the presenting a thesis of the GQW, the diploma of PhD of sciences was issued, everything would be logical and understandable. This would somewhat diminish the importance of the PhD diploma. One could say that defending a PhD thesis without postgraduate studies is one of the alternative ways, and the other is postgraduate study provided that the GQW has been successfully presented, but if such a GQW was presented, defending in the dissertation council would not be required.

If HAC would not admit presentation of the PhD thesis without a diploma on the successful completion of the PhD study, then everything would also be logical, although it would be more
difficult to raise the importance of the PhD diploma. However, it would also put the diploma of PhD study in its place.

If the PhD student goes to two PhD courses in parallel at universities of Russia and Europe, then either he gets an opportunity to present a PhD thesis. And since this can be done more quickly and, apparently, more easily (provided there is sufficient knowledge of the language), then after the defense the motivation for further studies in Russian PhD course disappears, since the PhD diploma is not worse than the PhD degree and by some criteria is better. In particular, a person with such diploma can be considered a foreign scientist, and the share of foreign scientists at the university is an important indicator for any university. If the graduate student does not get the opportunity to defend PhD thesis, then it means that there is no question of any joint educational program. At best, it is simply the joint supervising of one PhD student by two professors, one from the Russian university, the other from a European university. If the PhD student defends PhD and receives the corresponding diploma, then his further postgraduate education at Russian university becomes meaningless. It turns out that by signing an agreement on the implementation of a joint postgraduate curriculum, the Russian university creates all the conditions for excluding the probability of a successful graduate school at this Russian university. At the very least, one should recognize that in case of a reliable prospect for successful presentation of a thesis in the dissertation council, the motivation for PhD studies disappears. That is, the PhD course is actually designed for persons who are unable to defend the thesis at the appropriate "reasonable" time - until the end of PhD courses or during a short time after its endings. Such people may need a diploma to graduate from PhD courses.

On this basis, the development of a "double PhD study" is proposed to be implemented on the basis of the following principles.

1. Undoubtedly, it is necessary to conclude an agreement between two universities on joint implementation of the PhD-students program.

2. Both universities aim to promote comprehensively scientific research and preparation of the thesis, while each university provides and approves by its decision the scientific adviser. In fact, each of the universities must approve simultaneously two scientific leaders, both from their university and from the partner university. It is necessary to recognize this procedure as unusual; it can complicate the accreditation examination of the university.

3. It is possible that this agreement should permit simultaneous training of graduate students in post-graduate studies at both universities. However, if the curricula differ in terms of the duration of studies during a year, then synchronization is simply impossible. In this case, the agreement degenerates into an agreement on the appointment of two postgraduate leaders.

4. If the student has successfully defended at least one of theses - either a PhD thesis in the dissertation council under Russian scientific or educational organization, or a PhD thesis for a degree at foreign university, then in either of the two cases the training should be recognized as successful. At the same time, the organizations commit themselves (morally, since it will not be possible to impose other obligations) to ensure that the list of supervisors for the dissertation includes both leaders appointed from different universities. It seems impossible to guarantee this, because if the applicant finds such requirement to be insufficiently justified, or experts (representatives) from dissertational councils or other weighty scientific teams advise to facilitate the procedure for the defense and the approval of the thesis not to burden the thesis with such detail, which is generally unwelcomed, then, apparently, the applicant has the right to refuse from two scientific leaders in order to facilitate the passing of the thesis. The actual scientific adviser has hardly any legal means to influence such decision of the applicant.

Thus, it is clear that the procedure is not transparent, fragile, and at any time can stop working due to objective reasons.

Even such seemingly reliable mechanism as the availability of writing joint articles by a graduate student and both of his scientific leaders does not guarantee that in the end both leaders will be listed in the final version of the dissertation as scientific leaders.
In addition, it should be taken into account that the HAC is wary of the situation when two scientific supervisors are mentioned in the thesis. A cautious attitude is determined by the fact that in order to obtain the title of a professor, a certain minimum number of successfully defended students is required. Therefore, there is an interest in the order, which must be officially registered. Hence, it is possible to increase the number of successful students by the method of joint leadership, just as one can increase the number of articles by the method of co-authorship. Indeed, if two authors, each having the potential to write, for example, two articles a year and can provide them with double quotations, will include each other as co-authors, then each of them will have more than two but four articles a year that will be quoted four times. This will lead to an increase in the Hirsch index from zero to four in just one year, whereas for each author alone it would take three years (the first year - two articles with double quotations; the second year - two more articles with double citation each, which comprises in total six citations, and only the third year will result in the two-time quotation of these articles and give the Hirsch index equal to four). If such benefit from the double supervision is obvious, then the vigilance of the HAC inspectors (the expert council and the Presidium) is natural in relation to the theses in which the double supervision is indicated.

Perhaps, the situation will not be so tense if the thesis is written at the intersection of two related scientific specialties, one of which will be a supervisor and the other - a scientific adviser. But in this case, these specialties must be really adjacent, not related. For example, it is hardly possible to recognize adjacent scientific specialties related to each other, that is, such in the numbering of which the first four digits coincide, for example, “05.11.16 - Information-measuring and control systems” and “05.13.01 - System analysis, management and information processing”. Adjacent specialties in relation to each other may be recognized, for example, one of these specialties combined with “05.02.18 - Theory of mechanisms and machines”.

This question is quite subtle, since even within the framework of one dissertation council, there can be some scientific disciplines that do not coincide not only in the first four digits, but even in the second digit, as, for example: “01.04.14 - Thermophysics and Theoretical Heat Engineering”, and “05.14.14 - Thermal power plants, their power systems and units” or “01.04.10 - Physics of Semiconductors” and “05.27.01 - Solid State Electronics, Radiotelecommunication Components, Micro- and Nanoelectronics, Instruments for Quantum Effects” (see the website: http://www.nstu.ru/science/dissertation Sov).

Thus, it turns out that the program of double preparation at graduate school can be best realized between universities in the case when one university provides training in one scientific specialty, and another university - in another rather distant scientific specialty. At the same time, the inconvenience for the graduate student is that he will have to pass two examinations in the specialty, and his thesis, when considered by the expert council, will be highly likely to be subjected to additional review by the invited opponent. Perhaps, in the case of receiving a PhD degree, these difficulties are not so evident.

In addition, it should be taken into account that the mentioned deadline for completing the work according to European standards is shorter, the requirements for the thesis seem to be lower, which means that the probability of thesis defence in the Russian dissertation council is small.

4. Scientific Achievements in the Framework of Activities on Joint Educational Programs

Scientific results of cooperation consist in the results of joint research in the following areas:
- Numerical optimization of regulators, including regulators for multi-channel and non-linear objects [3–10];
- New regulator structures for feedback systems [11–13];
- Feedback regulators for robotic devices [14–16];
- Adaptive, complex and multichannel systems [17–19];
- Methods of geoinformatics [20–24].
5. Conclusion
Mobility of students and PhD-students in the framework of joint educational programs should be combined harmoniously with their research work, including writing joint articles in co-authorship with the supervisors from two universities from two different countries.

It would be very attractive to combine this form of mobility with participation of students or graduate students in summer or winter international schools.

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