Chapter # 25

DEVELOPMENT OF THE UNIVERSITY RESEARCH CENTER AND TRANSFER OF ITS RESULTS AND NEW KNOWLEDGE INTO TEACHING

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ABSTRACT
Education is an important area of the socio-economic life of any country, which serves to accumulate knowledge, experience and skills and to ensure the individual's intellectual development. Professional application of existing forms and teaching methods and active dissemination of new forms of education within the process of higher education is an important issue. For the successful implementation of new methods in higher education, it is necessary to define the requirements for the student, e.g., communication skills, technological skills and personality traits. No less important are the requirements for the qualifications of university teachers. E.g., technical skills, technological skills, consulting skills, lifelong learning skills, a process approach to solving different situations, and personal characteristics. The research and development in which they participate significantly contributes to the development of university pedagogues, as well as their institutions. The organisational structure of research and development plays an important role and can impact the educational process differently. The contribution deals with this in general and on the example of a specific technical faculty. The case study presents 3 main periods of the existence of one mechanical engineering research center at a technical faculty in an industrial region (from 2010 to the present). An overview of the main research results achieved, including income from contract research, is presented. An organisational change is suggested, which should bring about an improvement in the transfer of new research findings into student education.

Keywords: organising research and development, research centre, research institute, professor chair, research results, education.

1. INTRODUCTION

Education is a long-term process of shaping and developing a personality's cognitive, social and psychomotor components (a method based on progress in student development); educational results are confirmed by, e.g., diplomas and certificates (Neumann, 2002).

Studying can be characterised by using thought processes in learning about a given subject or topic. As part of the study, students research, search, analyse and verify through observation and experiment, use critical thinking, reflect and argue. Studying leads to developing intellectual abilities, problem-solving skills, the ability to communicate effectively, the ability to see mutual relationships between individual areas and realise studies in broader perspectives. Studying in educational institutions takes place in full-time (full-time), distance (remote) or combined form, and the study program at universities has three levels: bachelor's, master's and doctoral. All study degrees include programs offered by a specific educational institution (within the Czech Republic, accredited by the Ministry of Education, Youth and Sports for a certain period).

Teaching can then be described as a process based on the interaction of a teacher and a student. Teaching is not only concerned with imparting knowledge but also with developing skills and strategies for further learning (McKeachie et al., 1985). This view is also confirmed by Beutel's (2010) study, which shows that pedagogical interactions have different levels of complexity. Phenomenographic research has identified five categories: information transfer, instruction, facilitation, guided participation and mentoring. These categories form a continuum from simple knowledge transfer to complex partnership relationships, where the teacher acts as a "significant other" in the student's life. While lower levels focus on content and performance, higher levels emphasize active engagement, metacognition, trust and long-term development. Mentoring, as the highest form of interaction, goes beyond the school and supports lifelong learning, motivation and personal growth. The study thus shows that quality teaching requires not only knowledge, but also the ability to build relationships and support student autonomy. In this context, it is important to mention the analytical approach to teaching described by Schoenfeld (1999). His model of the teaching process characterizes the teacher's decision-making as a function of his knowledge, goals and beliefs. This approach emphasizes that teaching is not just the transmission of information, but a complex interaction in which the teacher chooses strategies based on pedagogical content, social aspects and value orientations. The model allows for detailed observation of how goals and action plans translate into specific classroom practices and provides a framework for understanding why teachers act in a certain way.

University teaching has specifics and assumes that a university student is intellectually mature and independent, interested in studying, thinking, discovering, and educating himself, and wants to achieve a university diploma. A university teacher should focus on questions about the quality and effectiveness of his teaching. An important aspect of the professionalism of university pedagogues is interest in students and respect for their personality. The decisive criterion for designing the teaching should be the student, which is a very demanding area of the pedagogical work of a university teacher. Given the subject he teaches, each university teacher should have created a certain set of teaching methods based on student activity. A prerequisite for success is deep knowledge of one's field, thorough preparation, communicative and management skills, and the ability to motivate and improvise. If the university teacher can create suitable conditions, the students can bring innovative ideas and propose solutions to the teaching. For example, Bligh (1993) and Ramsden and Ramsden (2003) formulated the main principles of higher education. These principles are followed by a modern approach, AlAfnan's Taxonomy, which emphasizes that effective teaching must develop not only students' cognitive abilities, but also their affective and psychomotor skills. This framework includes six levels from knowledge and understanding, through synthesis, evaluation and ethical reasoning, to application, creativity and lifelong learning and provides teachers with specific action verbs for goal setting and assessment. The integration of these domains supports not only intellectual growth, but also emotional intelligence, collaboration, adaptability and practical competence, which are key to preparing students for the complex challenges of today's world (AlAfnan, 2025). In line with these principles, recent research underscores that embedding sustainability into higher education curricula is equally critical for preparing graduates to address global challenges. The UAE (United Arab Emirates) provides a compelling example: guided by Vision 2021 and Energy Plan 2050, its universities integrate sustainability into teaching, research, and campus operations. Institutions such as Masdar Institute and Zayed University have launched interdisciplinary programs and experiential learning initiatives, while national strategies promote SDG alignment across curricula. These efforts aim to equip students with knowledge, values, and practical skills for sustainable development, foster collaboration with industry, and leverage technology for innovative solutions. Despite challenges—such as resource constraints and the need for faculty training—the UAE experience demonstrates how higher education can become a catalyst for ecological responsibility and global competitiveness (Abo-Khalil, 2024). These approaches are in line with the recommendations of UNESCO (United Nations Educational, Scientific and Cultural Organization), which emphasize the need to transform higher education through interdisciplinary research, strengthening partnerships and integrating sustainability into all areas of academic activity. Moreover, the UNITWIN (University Twinning and Networking Programme)/UNESCO Chairs programme demonstrates that international cooperation and knowledge sharing are key to a just and sustainable future, with universities playing a role as centres of innovation and social responsibility (UNESCO et al., 2022; UNESCO, 2023).

These principles are consistent with current demands for higher education in the context of artificial intelligence, as shown by Chan (2023). The integration of AI into university teaching must not weaken the role of the teacher, but on the contrary, support his ability to develop critical thinking, creativity and ethical reasoning in students. The proposed ecological framework for AI policy emphasizes that technologies should be a complement to pedagogical methods, not a substitute for them. Universities should create conditions for equal access to AI tools, transparent rules for their use, and support the development of digital and social competences so that students are prepared for the complex challenges of today's world.

Based on the above, it can be stated that learning can be defined as the process of changing the knowledge, skills, attitudes and other personal characteristics of an individual. Learning does not have to be associated only with studies, but continues throughout life. Through learning we gain experience and skills in areas that we are actively involved in; it can concern both university teachers and students, as well as technical or economic workers (Barrie, 2007).

Research conducted by the faculty enables students, including doctoral students, to solve scientific problems and develop the ability to apply theoretical knowledge in practice. This process is increasingly being implemented through cooperation between universities, businesses and other external partners, which brings a number of benefits. Joint projects create an environment where academic excellence is linked to the real needs of industry, and doctoral students learn a "bilingual" approach – orientation in both academic and business contexts. Such cooperation supports interdisciplinary research, the development of transferable skills (e.g., project management, communication, entrepreneurial thinking) and increases the employability of graduates outside academia. Key elements of successful schemes are joint planning, clearly defined objectives, the involvement of practitioners in supervision and the creation of trust between partners. These models not only ensure high quality scientific work, but also contribute to innovation, regional development, and long-term partnerships between universities and industry (Borrell-Damián, EUA - European University Association, 2009; Borrell-Damián, Morais, & Smith, EUA, 2015). Cooperation between universities and industry is important in the organization of scientific research activities, which includes practices such as collaborative research, contract research, consultancy or support for innovative companies (Johnson & Onwuegbuzie, 2004). As Breznitz and Feldman (2010) state, universities today fulfill the so-called "third role" in addition to teaching and research, they actively participate in the economic and social development of regions. This is manifested not only in technology transfer, commercialization of results and establishment of spin-off companies, but also in creating partnerships with businesses, supporting incubators and engaging in community projects. The current understanding of knowledge transfer between universities and industry is increasingly oriented towards the concept of “co-creation”, which goes beyond traditional linear models of research transfer towards interactive and two-way relationships. This approach includes not only joint research teams, laboratories and spin-off companies, but also wider ecosystems of cooperation, in which academic institutions, businesses and often the public sector or civil society are interconnected. The Organisation for Economic Co-operation and Development OECD (2019) emphasizes that effective knowledge transfer requires a comprehensive policy that combines financial, regulatory and “soft” instruments. In addition to technical mechanisms such as grant programs for joint projects, tax incentives or support for researcher mobility, the institutional autonomy of universities and public research institutions is key, allowing them to create their own transfer strategies. Current trends include the emergence of intermediary organisations (e.g., technology centres, incubators), the use of digital platforms for open innovation and the development of policies supporting spin-offs, in particular with an emphasis on the quality and sustainability of entrepreneurial activities. The OECD also draws attention to the importance of interaction between individual policy instruments – their synergies can enhance efficiency, while excessive complexity or conflicting regulations can hinder the transfer process. In this context, knowledge transfer becomes not only a technical but also an institutional and cultural process, the success of which depends on long-term strategic management and the ability to respond to digital transformation and global innovation networks.

At the same time, universities must address needs in two main areas: (1) establishing relationships between universities, research organizations and companies and (2) organizing and managing collaborative relationships in research and development (Perkmann & Walsh, 2007). These activities not only increase the innovative capacity of companies, but also contribute to job creation, the development of regional clusters and overall competitiveness.

As practice shows, the methods of organizing research and development at technical faculties are not uniform. They differ not only in their structure, but also in the degree of connection with teaching, the possibilities of using specialized capacities and the ability to support interdisciplinary cooperation. Each of these approaches has its advantages and limitations - from a close connection to the content of teaching to a wider connection with industrial practice. For better orientation, it is appropriate to present the three most common models that are applied at technical faculties. These models show how research teams can be formed, what organizational structures are proven and how research results are reflected in student education. The following part of the chapter provides a brief description of them and draws attention to the key advantages and risks that need to be considered when choosing them. After the general characteristics of R&D organization models, it is useful to show how these principles are applied in practice. Therefore, the text includes a case study that documents the gradual transformation of the research and development system at the Faculty of Mechanical Engineering of the University of West Bohemia in Pilsen. The study provides specific data on organizational changes, infrastructure, personnel, results and impacts on teaching and cooperation with industry.

The objective of this chapter is to analyze how different organizational models of research and development (R&D) at technical faculties influence the transfer of new knowledge into university teaching, and to evaluate the effectiveness of these mechanisms using the example of the Faculty of Mechanical Engineering of the University of West Bohemia in Pilsen.

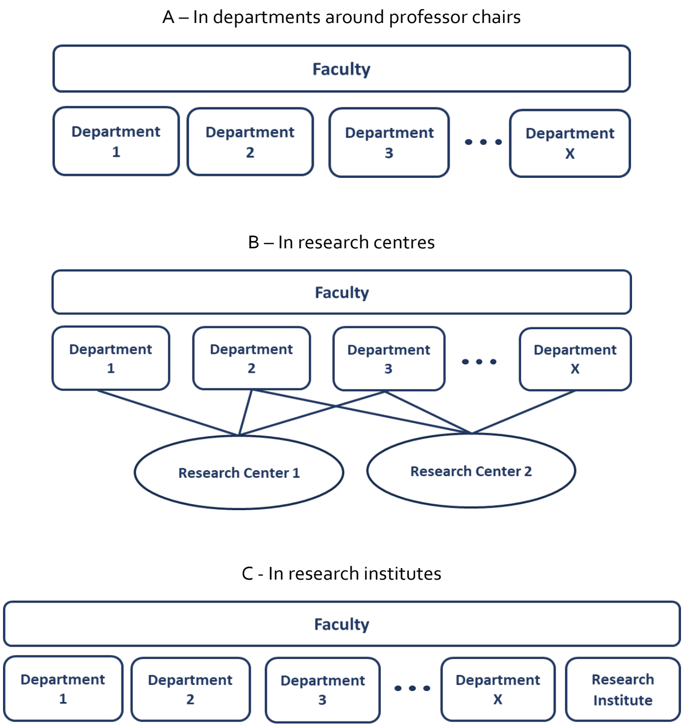
Specific research questions:

a) What are the main characteristics, advantages and limitations of models A, B and C in terms of knowledge transfer into teaching?
b) How did the establishment and development of the Regional Institute of Technology (RTI) affect the integration of R&D results into study programs and student involvement?
c) Which organizational and managerial factors support or, conversely, hinder systematic cooperation between research teams and teachers?
d) Which practical mechanisms (e.g., joint management of qualification theses, student involvement in applied projects, use of research infrastructure) are most effective for integrating R&D results into teaching?

2. ORGANIZATION OF R&D AT TECHNICAL FACULTIES

Fig. 1 generally shows three common ways of organising (and implementing) R&D at technical faculties.

Figure 1.
Scheme of organisation and implementation of research and development within the faculty.



2.1. Model A

R&D is organised within departments, and the research team is usually centred around a key professor or several key professors if the department has several partial units. The advantage of this arrangement is the closeness of the implemented R&D to the teaching content provided by a specific department. Disadvantages include a certain professional monothematic nature and closedness and the necessity to organise ad hoc cooperations in a more complex project/contract assigned to the department.

2.2. Model B

The need to solve more complex R&D tasks leads to establishing research centres. Employees from various departments put their specialised competencies and capacities into them. Or equipment. This leads to the intermingling of knowledge and approaches from several scientific fields. In some cases, this can lead to a certain "weakening" of the departments in terms of capacity, on the other hand, the feedback from the implemented R&D is directly transferred to the teaching by specific personalities. An indisputable advantage of research teams organised this way is an interdisciplinary approach to solving specific research and development projects. Research centres are often product-oriented, so it is necessary/practical to be managed by an expert with deep professional knowledge and respect in the given industry. Such an expert is sometimes not easy to find. Its education takes many years and requires close cooperation with practice (if we are discussing applied research and industrial development).

2.3. Model C

In some cases, faculties build their autonomous research institutes. These institutes differ from the above-mentioned research centres because they are larger and have a specific management and internal organisational structure similar to independent research organisations. Research institutes are mainly devoted to R&D and are organizationally next to the departments. It is advantageous if the structure of the laboratories of the research institute corresponds as much as possible with the teaching provided by the departments. In such a case, verbal methods, which are always the basic starting point for teaching students, can easily be supplemented with demonstration methods within the framework of a nearby research institute. The best students can then be enabled for practical active work, typically within the framework of doctoral studies or even during the preparation of diploma theses.

2.4. Linking Organizational Models with Knowledge Transfer to Teaching

The organizational structure of R&D fundamentally influences the intensity and quality of knowledge transfer to the educational process.

Model A, where transfer is natural because professors conduct both teaching and research, which allows for the immediate incorporation of current knowledge into lectures and seminars. However, this transfer is limited to narrow professional areas, as research takes place within a single department and has a monothematic character, without broader interdisciplinary cooperation.

Model B brings an interdisciplinary approach - research centers bring together experts from multiple departments, which allows for the enrichment of teaching content with new knowledge from different fields. The advantage is a wider scope and the possibility of involving students in complex projects that connect multiple disciplines. The disadvantage is that transfer depends on the personal involvement of researchers in teaching; if researchers focus only on projects, the connection with teaching weakens.

Model C achieves high research performance thanks to independent institutes, but without targeted measures there is a risk of isolation of research from teaching. Therefore, systematic involvement of researchers in the pedagogical process is necessary, for example through joint projects, syllabi editing and the supervision of qualification theses.

Practical mechanisms include the joint supervision of diploma and dissertation theses, the involvement of students in applied projects, the use of R&D results in lectures and the publication of technical monographs. These approaches correspond to the EUA international recommendations (DOC-CAREERS), which emphasize the importance of university-industry cooperation for the development of competences and employability of graduates (Borrell-Damián, 2009; Borrell-Damián et al., 2015), and to the UNESCO recommendations, which call for the connection of research, teaching and sustainable development through interdisciplinary approaches and global networks (UNESCO et al., 2022; UNESCO, 2023).

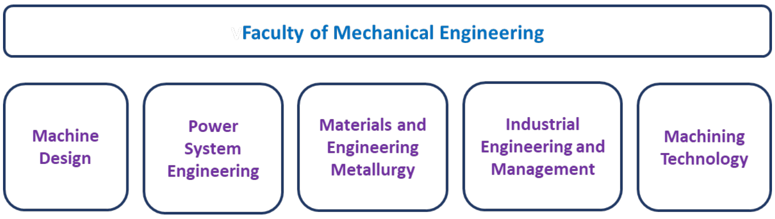
3. CASE STUDY

The previous paragraphs generally characterise 3 typical schemes of organising research and development. The case study gives a concrete example of its transformation over the years at the Faculty of Mechanical Engineering of the University of West Bohemia in Pilsen, Czech Republic

3.1. Model A

Until 2004, R&D was carried out at the Faculty of Mechanical Engineering of the West Bohemian University in Pilsen according to the classic model A, Fig. 2. It was primarily focused on working with doctoral students, and each department had its disciplinary council established to manage it. Specific R&D projects took place only sporadically, and orders from industry had a short-term character and were handled as a so-called supplementary activity.

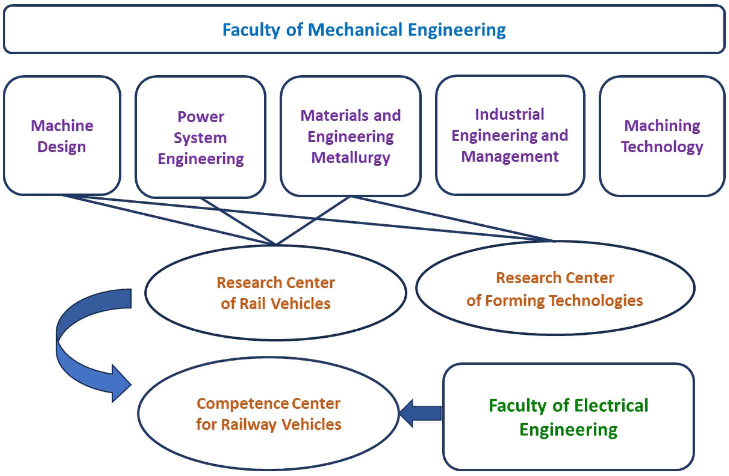
Figure 2.
Model A for the faculty.



3.2. Model B

In addition to the continuing original approach A, 2 research centres were established at the faculty in 2005-2006, to which the departments transferred part of their capacities, schematically see Fig. 3.

Figure 3.
Model B for the faculty.



Research Center of Rail Vehicles that only dealt with the mechanical parts of locomotives, vehicle units, wagons, trams and metros. The research center had two other external research organisations and one rolling stock manufacturer as partners. Research Center of Forming Technologies dealt with hot and cold forming technologies and surface and volume forming. It was intensively devoted to improving the useful properties of metals by thermomechanical processes. The research center had two other research organisations as partners. The main goal of both research centers was to achieve application results, i.e., patents, utility models, functional samples and verified technologies. For example, the high-strength hollow shaft was awarded a gold medal for the best innovation at the International Engineering Fair in Brno. Of course, publication activities also took place, but they did not determine the centres' success in their evaluation by the subsidy provider, the Ministry of Education, Youth and Sports.

In 2009, the Technological Agency was established in the Czech Republic, which centralises state support for applied research and development (which until then was fragmented among many providers). In connection with this, the Research Center of Rail Vehicles was transformed into the Competence Center for Railway Vehicles, and research was already focused on the vehicle as a whole, i.e. not only on its mechanical part but also on its drives. Some safety issues of their operation were also addressed; therefore, the related infrastructure was at stake. Therefore, the Faculty of Electrical Engineering's capacities were also involved in the centre's activities. The center had 11 other partners across the Czech Republic, of which 4 were research organisations, 3 were end manufacturers, and 4 were component manufacturers. Around a hundred application results were achieved. Most were applied in practice since they were created in cooperation between research organisations and businesses. The transfer of new knowledge from research and development to teaching occurred naturally through the human capacities working simultaneously in research centers and departments. A bonus not only for students but also for professionals was publishing a series of books devoted to various technical aspects of the construction of rail vehicles.

3.3. Model C

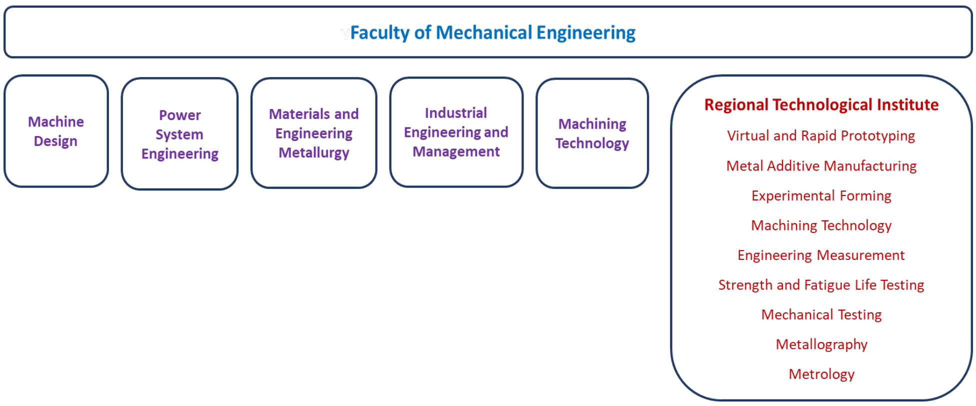
With the support of the European Regional Development Fund, a separate unit called the Regional Technology Institute (RTI) was built at the Faculty of Mechanical Engineering between 2011 and 2015. Around 60 new jobs were created, half under age 35, focused exclusively on research and development. A modern infrastructure for R&D was acquired. The capacities of the two aforementioned research centers were transferred to RTI. RTI was put into full operation in the middle of 2015, and its institutional support was terminated on 30 June 2019, which, until then, represented roughly half of the financial resources required for the operation of RTI. Since then, institutional support for RTI has been in the minority, and RTI workers obtain most funds (up to 80%) from grant agencies in the form of subsidies for accepted R&D project proposals and, of course, also as sales for solving research contracts for businesses. Most subsidised projects are solved in cooperation with the industrial sphere, and other domestic research organisations often participate. International projects are also handled.

The benefit of RTI for faculty development is indisputable. Most of the results are translated into practice thanks to the developed cooperation with the business sphere. Some results of own research have received public recognition. The number of employees of the faculty, which can now clearly be described as a research faculty, has almost doubled.

The faculty has modern equipment, so students can go on excursions in their home environment (one of the demonstrative teaching methods). It is possible for students to carry out their calculations and experiments here as part of their qualification work (practical teaching method). The best doctoral students work in teams solving complex multidisciplinary R&D projects, which can be considered a participatory learning method (Honzikova, 2015).

The structure of the RTI laboratories was not conceived in such a way as to have the greatest possible impact on the quality of teaching, but above all in such a way as to enable a complete cycle of development and testing of some engineering products. This can be demonstrated in the example of additive technologies, where to develop a new component successfully, it is not enough to have a suitable printer but the developers need to have software for its design and optimisation, postprocessing (heat treatment and surface treatment) and various testing. In the organisational structure of the faculty, RTI stands next to (at the same level as) the departments, see Fig. 4.

Figure 4.
Model C for the faculty.



To date, the administrative and research team of the RTI has completed 3 characteristic five-year periods:

I - phase of building, period 2010-2014 (project design, construction of a new hall, acquisition and commissioning of new equipment with full financial support, start-up grant for gradual recruitment of research staff and step-by-step expansion of research and development activities);

II - sustainability phase, period 2015-2019 (mandatory full occupancy of newly created jobs and operation of purchased infrastructure, primarily for the implementation of research and development, were partially financially supported);

III - follow-up, independent operation, period 2020-2024 (research and development within the open market).

Table 1.
Results of the RTI research center.

Main categories of results achieved in the evaluated periods of RTI operation	Period I	Period II	Period III
	2010 - 2014	2015 - 2019	2020 - 2024
Publications	127	511	195
of which registered in WoS or Scopus	not registered	93	95
Applied results	88	295	235
of which patented	21	39	47
Contractual research *thousands of EUR*	584	3 815	3 701

In all of the above phases, the measures of success of this relatively independent research center were the research results achieved. The results can be divided into two main categories: publications and application results. Cooperation with industrial companies is best measured by income from contract research or services such as accredited tests and expertise. Table 1 shows the structure of the results.

High-quality, application-oriented research and development primarily benefit cooperating industrial enterprises. The table illustrates the consolidation of industry partnerships and an improvement in the quality of both principal categories of outcomes. Additional evidence of increased excellence in research and development includes a higher share of publications indexed in recognised scientific databases and a growing number of original, patentable results.

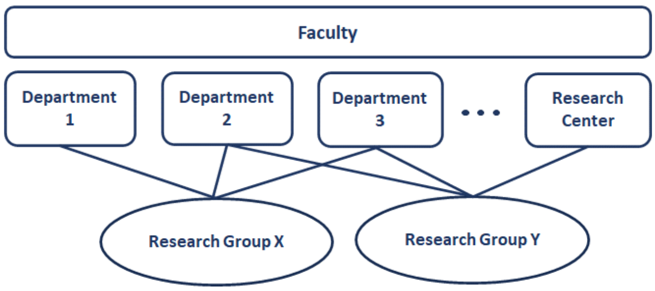
Humboldt's theory that research and teaching are inseparably intertwined within the university environment has been confirmed in practice. At the same time, however, it has become evident that the quality of teaching is not directly correlated with the quality of research and development. Similar conclusions have been reached by several international studies.

Within the existing organisational structure, the faculty has indeed increased its research output; nevertheless, this has not automatically translated into enhanced quality of education, as researchers have participated only marginally in the teaching process. Over time, the transfer of new knowledge from the RTI research center to individual departments has proven insufficient, and the departments have also begun to fall behind in terms of equipment. This challenge must be addressed.

A possible way forward lies in targeted cooperation between the heads of RTI laboratories and departmental chairs, the systematic involvement of leading researchers in the teaching process, and the joint implementation of R&D projects. An alternative would be to redefine the role of the RTI research center and manage it according to the concept of a combined research–educational unit.

Research and teaching activities are therefore currently being transformed into a model approximating the above-described Model B (see Figure 5). Academics and researchers are expected to collaborate in discipline-oriented research groups, the establishment of which is now under consideration by the faculty leadership.

Figure 5.
Plan for the reorganisation of research activities.



Researchers will gradually assume a more substantial role in teaching. At the same time, it is recognised that university instruction has its own particular demands. Success requires not only the deep subject expertise that new lecturers have acquired during their work at the RTI research center, but also thorough preparation, communication and managerial skills, and the ability to motivate and improvise. University lecturers should, therefore, place greater emphasis on the quality and effectiveness of their teaching.

An important aspect of university teachers' professionalism is, above all, their genuine interest in students and respect for their individuality. The decisive criterion in designing instruction should be the student, which constitutes one of the most demanding areas of a university teacher's pedagogical work. When university teachers succeed in creating appropriate conditions, students can contribute innovative ideas and propose solutions for both teaching and research.

4. CONCLUSION

The analysis of the development of organizational models of research and development at technical faculties confirms that the way they are structured fundamentally affects not only the effectiveness of scientific work, but also the quality of knowledge transfer into the educational process. Experience from the transformation at the Faculty of Mechanical Engineering of the University of West Bohemia shows that increasing research output alone does not automatically guarantee improved teaching. The Humboldt principle of linking research and teaching is fulfilled in practice only if mechanisms for systematic cooperation between research teams and teachers are created.

From the perspective of strategic management, the following factors appear to be key:

Institutional integration: Autonomous research institutions (Model C) bring a high degree of professional specialization and excellence, but without targeted measures, they risk being isolated from the pedagogical process. It is therefore recommended to introduce hybrid models that connect research capacities with teaching through joint projects, shared laboratories and the participation of researchers in the creation of study plans.

Personnel policy: Successful knowledge transfer requires not only professional erudition, but also pedagogical competences of researchers. Systematic inclusion of didactic training, mentoring and support for the development of communication skills is essential for researchers to become quality university teachers.

Technological and infrastructural background: Modern research infrastructures, such as RTI, represent significant potential for demonstrative and participatory teaching methods. However, it is necessary to ensure their accessibility for students of all levels of study, not only for doctoral students.

International and interdisciplinary dimension: Trends in the field of higher education (UNESCO, EUA, OECD) clearly point towards linking research with global challenges, in particular sustainability and digitalization. It is therefore recommended to expand cooperation with international partners and to include the principles of open innovation and co-creation of knowledge in the educational process.

In the long term, it is essential that technical faculties adopt the concept of a "learning institution", where research, teaching and the third role of universities (social responsibility, technology transfer) form a synergistic whole. Only in this way can we ensure that graduates will have not only deep professional knowledge, but also the ability to adapt, think critically and collaborate interdisciplinary – competencies that are key to solving the complex problems of contemporary society.

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Short biographical sketch: She received master degree in Electrical Engineering in 2012, and in 2017 she defended her work and made the title Ph.D. in Electrical Engineering at the Department of Technologies and Measurement at the Faculty of Electrical Engineering at the University of West Bohemia in Pilsen, Czech Republic. Her main research interest is heat transfer in electrical insulation systems. She is engaged in modelling and numerical analysis. Another area of its interest is sustainable development, ecology and the life environment. In addition to the scientific area, she was an employee of several manufacturing companies and gained knowledge of the production processes and product quality settings (the person responsible for the organisation of customer visits and audits from the compilation of the audit program to the resolution of corrective and preventive measures identified). She holds the international certificate Quality Management System - Head Auditor ISO 9001: 2015 with an International Exam.

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