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Review

RESEARCH-BASED TECHNOLOGY EDUCATION – THE EDURES PARTNERSHIP EXPERIENCE

EDUKACJA OPARTA O WYNIKI BADAŃ – DOŚWIADCZENIE PARTNERÓW PROJEKTU EDURES

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Abstract

The paper presents the state regarding practices in teaching at partner universities of the EDURES project and current approaches supporting research-based education. It also presents the needs of various groups of stakeholders formulated on the basis of survey results. Moreover, the paper proposes tools and strategies which are useful if research results are implemented in teaching programmes at technical universities (research-based lectures, e-learning, web portal methodologies, wizards, etc). It is finally stated that research-results implementation into teaching processes is possible by the use of various tools and approaches proposed by the EDURES partnership and has the potential to be appreciated by students, academics and external stakeholders.

Keywords: research-based education, technology, digitalization

Streszczenie

Artykuł przedstawia opis zagadnienia dotyczącego nauczania opartego o wyniki badań oraz aktualnie stosowane praktyki partnerów projektu EDURES. Przedstawiono potrzeby interesariuszy na podstawie wyników ankiet. Przedstawiono także narzędzia i strategie użyteczne podczas wdrażania wyników własnych badań w programach nauczania na uczelniach technicznych (wykłady oparte na wynikach badań, e-learning, metodyka portalu badawczego, narzędzia internetowe). Należy stwierdzić, że wdrażanie wyników badań w procesach nauczania jest możliwe przez zastosowanie różnych narzędzi i w oparciu o różne strategie, które zostały opracowane w ramach projektu EDURES i mogą być potencjalnie docenione przez studentów, akademików i zewnętrznych interesariuszy.

Słowa kluczowe: edukacja oparta o wyniki badań, technologia, digitalizacja

1. Introduction

The centuries of technical academia existence have revealed various teaching & learning methodologies which have been implemented, revised, updated many times due to the changes of technology. Nowadays, there are a lot of educational institutions (i.e. higher education institutions such as universities focused on technology) which, in our opinion, are involved in a race together with R&D departments of big technological companies operating in industry. The mission of universities and approaches that are used by academics in the teaching processes nowadays should be adjusted once again to modern challenges such as enormous mobility of people, flow of data, the use of artificial intelligence, etc. Moreover, content of study programmes should enable learners to obtain the skills useful in modern technological environments of firms. These skills must be significantly separated from those which are gained in the technical high schools and strongly focused on shaping scientific skills of higher education learners. This is important because the scientific skills help students to search for the best technological solutions in the real industrial environments by using scientific approaches and methodologies. Rapid transfer of knowledge, that concerns recent scientific achievements of academics, within different forms of classes (e.g. lectures, laboratories) brings various benefits for academics, students and technological companies such as evaluation of achievements by wider audiences, increase of students' satisfaction, faster knowledge transfer to the industry. For this reason, the classes with students should be used efficiently for presenting modern science by using modern approaches. Authors have decided to prepare the paper within the EDURES project which is performed within the ERASMUS+ programme in order to present project team ideas on research-based education. The presented content is mainly adjusted to the mechanical engineering and civil engineering scientific disciplines. These technological disciplines have various research methodologies.

Various teaching methodologies such as problem--based learning (Li Wenli, 2012; https://en.wikipedia.org/wiki/Problem-based_learning 30.08.2023) or project-based learning (https://en.wikipedia.org/wiki/Project-based_learning 30.08.2023) have been studied so far in order to improve effectiveness of teaching and learning. This is crucial due to the acceleration of technological developments worldwide and actual requirements of customers. An example of such action is Aalborg University in Denmark, where students work in groups applying problem oriented methods in preparing projects of a high academic standard according to the pedagogical model of the University - the Aalborg model for problem based learning (https://www.en.aau.dk/about-aau/profile/pbl 22.09.2023).

In addition existence of various papers should be mentioned. For instance, the study of Soledad Ramirez-Montoya et al. is focused on providing perspectives on the future of educational programs by analysing trends in educational programs' designs, students and professors' needs for innovative education (Soledad Ramírez-Montoya María et al., 2021). Another paper authored by Gębczyńska-Janowicz proposed utilization of virtual reality in education (Gębczyńska-Janowicz Agnieszka, 2020).

However, research-based teaching and learning seems to be important area of development due to acceleration of implementation of innovative solutions and technologies in various industries. It should be noted, in this context, that improvements of teaching methodologies have been the crucial point of research activities so far. Shou et al. found that combining scientific research projects with experimental teaching has a significant impact on teaching effects and can improve students' interest in experiments (Qingyun Shou et al., 2014). Paper of Brenner and Adamovic provides an overview of approaches that might be considered in order to successfully integrate European research projects into engineering teaching method (Brenner Werner et al., 2020). The study (Marshall Jill et al., 2018) compares a project-based cornerstone course with the traditionally- taught introductory course in civil engineering. The mentioned paper also points that interviewed students indicated that they recognized and appreciated that the project-based course enabled them to do real engineering. Moreover, the paper of Mariken et al. explores how to strengthen the research-teaching nexus (TRN) in university education, in particular, how to improve the relation between policy and practice (Elsen Mariken et al., 2009). It is stated that if a university chooses to strengthen the research-teaching nexus in undergraduate curricula, students are more often involved in the role of participants in research. Another research gap regarding TRN was filled out by Clark and Hordosy (Clark Tom et al., 2019). They, inter alia, presented how the nexus can also often serve to exclude students as much as it includes. On the other hand Munthe E. et al. analysed research-based teacher education. They inter alia analysed the role of inquiry and research in abovementioned area (Munthe Elaine et al., 2015). The paper proposed by Brew et al. takes into account issues not only for the education of teachers, but also for the introduction of research-based learning in higher education (Brew Angela et al., 2020). It should be stated in the conclusion following

opinion of Iivari and co-authors of paper (Iivari Netta et al., 2020) that research-based education needs to be updated and it is a main reason for the study which is presented within this paper in the technology-related journal.

2. EDURES partners practices in the area of teaching programmes at technical universities

2.1. General structure of programmes at EDURES partner universities

The typical teaching programmes of the Rzeszów University of Technology offers full-time and part-time studies. Full-time studying is possible during week days (Monday – Friday) while the part time classes are organized within weekends. Teaching programme is nowadays formulated as a set of semesters divided into modules. The modules are planned as separate courses in the selected area. For instance, a module may concern CNC machine tools programming, fundamentals of mechanics, machine technology basics, etc. Usually, last semesters are mostly focused on a diploma thesis preparation. In the EU zone there are usually 2 or 3 cycles at bachelor, master and doctoral level respectively. For instance, at Rzeszów University of Technology the first cycle consists of 7 or 8 semesters depending on the type of studies (full time or part time). The second cycle (master degree) is shorter and lasts 3 semesters. Number of modules per one semester may vary. However, a number of ECTS points is always the same and equals 30 points per every semester. Number of the ECTS points is linked to the planned number of hours that are assigned to student workload (i.e. 1 ECTS point is assigned to 25 – 30 h). Module coordinators should assign workload to the specific forms of classes. Selected modules are completed by students within the examination procedures. Other modules are passed on the basis of simpler tests, projects, presentations, etc. Modules may be divided into typical forms of classes such as lectures, laboratories, exercises, projects, etc.

Regarding the structure of studies at the National Technical University of Athens (NTUA), it is organized into distinct academic semesters, with each semester carrying a value of 30 credit units. The courses offered within the various Schools are designed to span a single semester. The entirety of studies across all Schools encompasses ten semesters, divided equally between five in the fall and five in the spring. The tenth semester is dedicated to the completion of the diploma thesis. On average, each semester involves the coverage of 30 credit units and spans a duration of 18 weeks. Among these weeks, 13 weeks are exclusively allocated for instructional purposes, 2 weeks are set aside for breaks during Christmas and Easter, and the final 3 weeks of each semester are designated for the administration of examinations related to the courses taught during that semester. In the fall semester, the week following the conclusion of final exams is designated as a period for vacations or potentially specialized educational activities. The NTUA plans and organises its educational programme following some main principles. More specifically, to maintain and to enrich the basic five-year diploma degree course structure, which is equivalent with the master's degree, with a strong theoretical background in the applied sciences and technology with an appropriate range and number of courses, and high standards in the diploma thesis. Furthermore, there is a continued emphasis on enhancing studies, with a focus on fostering coherence and profound academic depth. This approach is designed to effectively address both present and future development requirements. It involves a systematic adjustment to the educational approach of active learning, ensuring a methodical alignment. Furthermore, there is an intention to bridge the gap between theoretical studies and practical application, whether it is within a professional context or oriented towards research. Ultimately, this concerted effort seeks to introduce novel vistas in the realm of scientific and technological education (26.09.2023, https://www.ntua.gr).

Finally, continuing the abovementioned, concerning the assessment of the instructional process at the NTUA, surveys (similar to the ones at the Rzeszów University of Technology) are utilized with the purpose of identifying any deficiencies in the provided education and consistently enhancing its caliber. This proactive approach aims to implement fresh teaching methodologies that amplify student engagement through various means, such as expanding and refining practical laboratory work, incorporating multimedia tools, employing electronic questionnaires for evaluation, granting access to digital libraries and resources via faculty members' personal web pages, and fostering improved interaction between academic staff and students. The questionnaires are distributed to students between the 7th and 10th week of each semester by the School Offices, during courses. They are optional and anonymous, and are offering vital information for achieving the above aims.

Recognized as a scientific institution in Germany, the Furtwangen University (HFU) stands out for its excellence across the following domains (https://www.hs-furtwangen.de/en/who-are-we/profile-mission-statement, 30.08.2023; https://www.hs-furtwangen.de/en/programmes 30.08.2023):

- high quality and innovation in teaching,
- strong practical focus through collaboration with industry,
- international focus,
- applied research and education,
- continuing education and lifelong learning,
- cooperation and motivation,
- social responsibility and safeguarding of the future.

The Furtwangen University offers various bachelor's and master's programs at nine faculties. The bachelor's program lasts seven semesters, master's degree program lasts three semesters and is completed in a master's thesis during the third semester. Modules comprise one or more courses evaluated through written exams, practical work, etc. Main examination period, similarly to other partners of the EDURES project, is set at the end of semester.

OECD library indicates that the Italian Higher Educational System operates in an competitive framework of science, innovation and knowledge economy, which, however, faces some challenges. For instance, among G20 economies, Italy had the 5th-highest penetration of machine-to-machine (M2M) subscriptions in 2017 (OECD, 2017b). Italy also accounted for almost 4% of the world's top 10% most-cited scientific publications in 2016. (OECD, 2017b). (26.09.2023, https://www.oecd-ilibrary.org).

The Italian University System is organized in three cycles. Within these cycles academic qualifications, that can be obtained, are associated with each cycle. They allow students to progress with their studies, to participate in public recruitment competitions and to enter the workplace and careers in the professions. University study courses are structured in credits. A university credit (CFU) is usually equivalent to 25 hours of study by a student, including individual study in the total. The average quantity of academic work performed by a full-time student in one year is by convention measured as 60 CFUs. The CFU system is equivalent to the ECTS system. Degree and master's degree study courses that share goals and educational activities are gathered in 'classes' (degree classes). The education contents of each degree course are determined autonomously by each single university: they are obliged to include certain educational activities (and the corresponding number of credits) fixed at a national level. These requisites are established in relation to each class. The qualifications in the same class all have the same legal value (26.09.2023, https://www.cimea.it).

To what is considering the University of Ferrara which operates close to Centoform (the EDURES project partner), it offers a bachelor's degree program in Mechanical Engineering by the Department of Engineering, which is an open access, with a course of study organized into three years of study. The educational activities of the degree program take place at the Scientific-Technological Pole of the University of Ferrara. The normal duration of the course of study is three years. The degree is awarded after the successful completion of all activities in the curriculum studies and the acquisition of 180 credits (26.09.2023, https://www.unife.it/en).

2.2. Preparation of learning outputs

Learning outputs are usually prepared in the area of knowledge, skills and social competences. Teachers usually have a freedom in the case of module outputs definition. However, outputs which are assigned to the field of study (teaching programme) are defined for all modules and teachers have to assign module learning outputs to programme learning outputs.

There are different approaches used by the teachers but usually at least one module learning output is defined to the specific form of class work (e.g. one learning output which concerns knowledge may be assigned to the lecture or learning output which concerns skills may be assigned to laboratory or social competence may be assigned to laboratory or other form of class work).

There are specific verbs which are used to describe the learning outputs goals. These learning outputs should be clearly stated and understood by academia and stakeholders. The learning outputs which are defined within curricula should be also reachable and the entire course should be consistent. There might be a challenge or even a problem in the process of learning outputs preparation for teachers who are not experienced and also for those who were used to other system requirements in the past.

2.3. Currently used didactic methods

Most teachers in the EDURES partnership use typical didactic methods. In the case of lectures, lecturers present the content within oral presentations with the support of boards and projectors. Nowadays lectures may be performed in the university classrooms or on-line. Laboratory is a specific type of classes that requires the use of equipment - test stands, computers, machines, etc. Students work in smaller groups in this case. Projects usually require utilization of calculations regarding specific topics (e.g. construction of machine) and are performed on the basis of some input data given by a teacher. In some cases, laboratory classes and projects are difficult to be distinguished due to various approaches used within class, which are typical for both class types. It can be observed that practical forms of class organization and

learning activisation has a great potential and are appreciated by students.

Academic teachers require practical knowledge about active learning methodologies; many universities have established learning and teaching centers to address this need. In the United States, such centers have been operational for over a decade, e.g. ABLconnect at Harvard University, The Yale Poorvu Center for Teaching and Learning, the Center for Teaching & Learning at UC Berkeley, Georgia College and State University, Boston University (https://ablconnect.harvard.edu/, https://poorvucenter.yale.edu/, https://www.gcsu.edu/ctl, https://www.bu.edu/ctl/, https://teaching.berkeley.edu/home 22.09.2023). This practice is also gaining popularity in Polish universities, e.g. Center for Modern Education at Gdańsk University of Technology, the Center for Didactic Improvement and Tutoring at the University of Gdańsk, the Center for Didactic Excellence at Wrocław University of Science and Technology (https://cne.pg.edu.pl/, https://cddit.ug.edu.pl/, https://cdd.pwr.edu.pl/ 22.09.2023). Rzeszów University of Technology is also undertaking initiatives in this direction, recently hosting regular meetings and methodological workshops for academic teachers on modern education. In 2023, the Center for Didactic Excellence formally commenced its operations also at this University.

Various comparisons of the teaching methodologies revealed that partners of the strategic partnership in the EDURES did not have worked out strategy of the recent research-results implementation into teaching processes. Structures of programmes have revealed various similarities and differences, inter alia, described above. Research results implementation activities have been performed by individual teachers mostly.

3. Analysis regarding the best practices and trends in research-based education

3.1. Advantages of research-based education

Research-based education focused on utilization of ongoing or recent results can be characterized by various advantages.

Authors would like to indicate the following advantages of research-based education:

1. Students have the actual knowledge in the areas of research which are crucial for academia.
2. Students pay attention to the discussed topics due to a novelty of taught problems.
3. Dissemination of research results to the companies which employ graduates is extended and ideas developed in universities may be easily transferred to the industry (in particular influence on local companies may be increased).
4. Students who perform their own investigations based on the research results of academics may have a better understanding of real research gaps and challenges of science.
5. Academic community is encouraged to publish high quality research results.
6. Classes may be understood as much more attractive because topics and scope of classes must be updated and adjusted to the changing state of the art resulting from research achievements.
7. Level of classes is adjusted to the requirements of the higher education system.
8. The dissemination of research results may lead to acceleration of innovative ideas - both in teaching and research area.

3.2. Research activities of students

Students usually conduct research within scientific groups, in the process of diploma thesis writing or within classes (i.e. laboratory classes). Scientific groups, mentioned also in further part of the paper, are usually started and run by students who are significantly active persons and want to obtain new knowledge and additional skills. In the case of the diploma thesis writing, mainly in the case of master theses, students are encouraged to conduct research or deeper scientific analysis.

Research conducted within classes depends on learning outputs defined by teachers and may be a modern and attractive form of classroom activities. One such approach is the problem-based learning (PBL), that offers the opportunity to undertake research work and conduct scientific research within a given subject and education course. It allows for the analysis and resolution of real-world problems in collaboration with the economic environment. Within the classes, students can carry out research work conducted as part of university projects and orders, thus staying close to current research problems. In the model developed at Aalborg University, classes conducted with the PBL methodology are the main stream of education every semester (these subjects are assigned 15 out of 30 ECTS points). Students also acquire the knowledge necessary for formulating research problems and conducting team projects, including classes on soft skills covering, among others, interpersonal communication, conflict resolution, project management, and time management. The outcome of this work can be scientific articles written jointly by students and academic researcher.

Introducing the latest scientific research results into the educational process is also possible through

scientific interest groups, sometimes operating within the structures of units of individual universities. It allows students to engage in scientific activities, providing them with an opportunity to learn research techniques and methodologies. Within these groups, students can collaborate on research projects, discuss the latest scientific developments, and explore innovative solutions to contemporary problems. This involvement not only fosters a passion for learning and discovery but also allows students to develop practical skills and gain experience in their field of interest, preparing them for future research endeavors and professional challenges. The results of such involvement may include participation in scientific conferences and authorship of joint publications.

3.3. Implementation of research in teaching

The general idea regarding research-results implementation is based on the need for access to the current research results by academic community and partners. The word 'current' has a special and crucial meaning in this methodology. The abovementioned methodology is shaped in order to teach teachers how to disseminate research results effectively in order to achieve advantages for technological knowledge and innovation acceleration. This methodology also encourages to search for the benefits resulting from 'publication' of research results not only in journals but also to own students.

The EDURES methodology suggests various forms of research results implementation in teaching processes.

The exemplary approaches are as follow:

1. Utilization of open access journal articles into teaching process.
2. Creation of digital platforms which enable to disseminate research results of academia amid academic community members.
3. Starting internal scientific discussions.
4. Implementation of current research results into e-learning environment and possibility of their updating in the future.
5. Asking industrial partners for their opinion regarding current industrial problems and implementing their suggestions into teaching on the basis of own achievements.

Research results implementation methodologies will potentially be one of crucial points in the future of education.

4. Surveys and their results

The confirmation of the need to conduct classes with university students based on didactic materials including the results of scientific research are the results of the surveys that were conducted among students, employees of universities, graduates, and employers. The survey was carried out as part of the Intellectual Output 1 entitled *'Guide for educators regarding the utilization of research results in technology education'* of the EDURES project. The responses to the selected questions included in the above-mentioned surveys are presented below (Figs. 1-7). The following graphs show the selected results of the survey conducted for graduates.

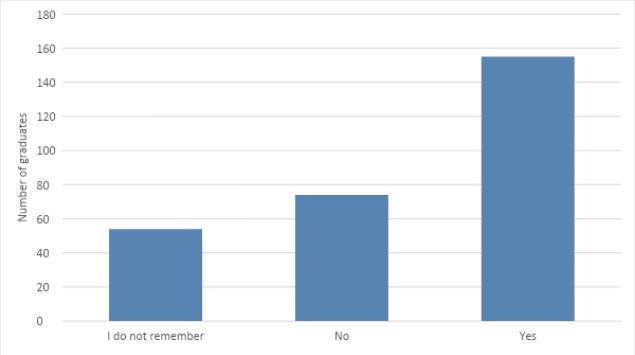

Fig. 1. Question: Did you know about any research conducted at your university during your studies?

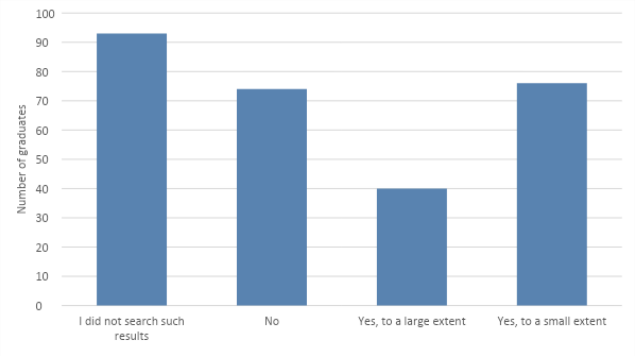

Fig. 2. Question: Did you have access to research results (papers of academics, experiments and test stands, scientific groups, and their achievements) of the university you graduated from?

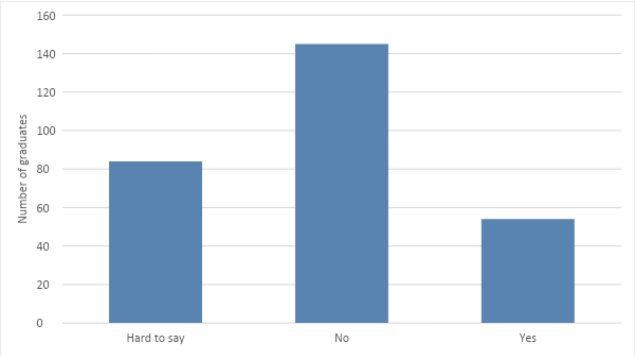

Fig. 3. Question: Did research results of your university enable you to develop your career?

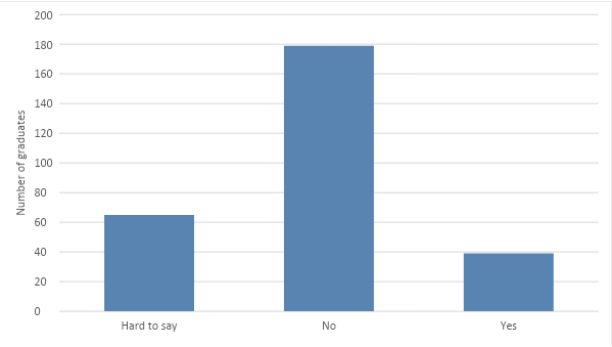

Fig. 4. Question: Did research results of your university enable your firm to develop something new?

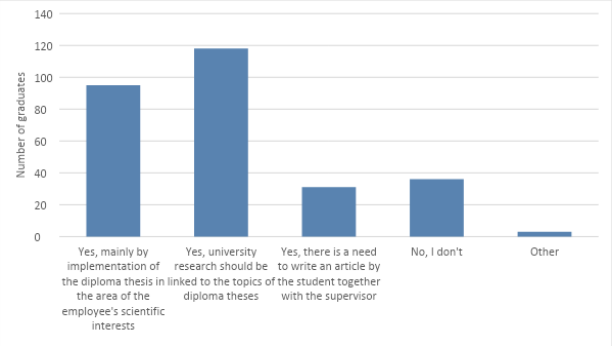

Fig. 5. Question: Do you think that conducted research could be used in diploma theses?

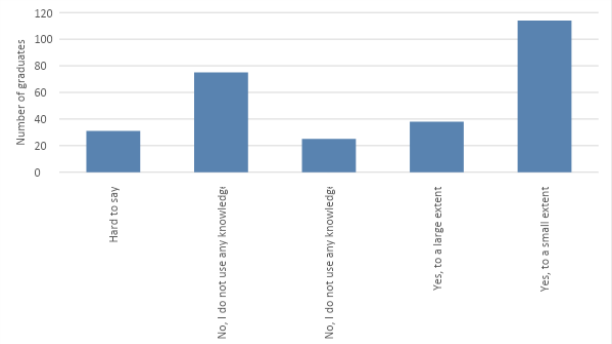

Fig. 6. Question: Do you use the knowledge and skills resulting from scientific research in your current workplace?

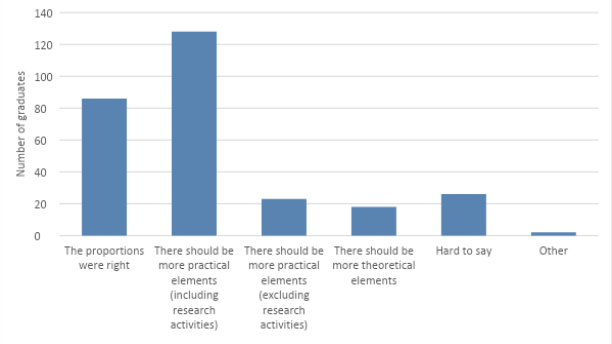

Fig. 7. Question: How, from the time perspective, do you evaluate the relationship between practical, theoretical classes and these which build scientific knowledge and skills of students at your university?

Based on the analysis of the presented results of the surveys, the following conclusions may be issued:

1. Most graduates knew about research conducted at their university during their studies. However, there is also a large group of respondents who have no such knowledge.
2. Most respondents did not search for any research results of the university they graduated from. There is also the large group of graduates who did not have the access to such results or have it to a small extent.
3. Most graduates indicated that research results of their university did not enable them to develop their careers.
4. Most respondents said that research results of their universities did not enable their firms to develop something new.
5. The largest group of graduates indicated that research could be used in diploma theses. Most respondents said that research activities should be linked to the topics of diploma theses.
6. The largest group of respondents think that they use the knowledge and skills resulting from scientific research in their current workplace to a small extent. Moreover, there is the large group of graduates who do not use any knowledge and skills resulting from scientific research in their professional work.
7. Most respondents think that there should be more practical elements, which also include research activities, during their studies.

In turn, from the analysis of the surveys for employers, the following conclusions may be raised:

1. Most employers expect research qualifications from graduates of technical universities.
2. Most respondents think that they should have an influence on the teaching programs and research of higher education institutions.
3. Most employers would encourage their employees to study at a university which offers research skills to students.
4. Large number of employers think that research qualifications are obtained when studying at technical universities. Moreover, graduates of technical universities have extended knowledge, skills, independence, and problem-solving attitude according to respondents.
5. The most respondents are interested in knowledge of their employees graduating from higher education institutions regarding innovations/patents/publications produced by local universities.
6. Most employers do not know any research results produced at regional universities that

have a strong impact on manufacturing firms or know only a few of them.

The detailed survey results for all groups of respondents are presented on the EDURES website. The results of the conducted surveys, despite the large number of graduates who are aware of scientific research conducted at universities, clearly indicate the need to base the didactic process also on the results of research conducted at universities. The obtained answers confirm that the latest research results should be reflected in teaching. Therefore, new teaching materials should be developed and/or modification of currently used materials should be made. New and/or modified materials should incorporate more of the results of ongoing research. Proposals for such materials were created within the EDURES project, and selected ones are presented in the following sections of this article.

5. Lectures including the results of scientific research

The results of the surveys, which are presented in the section and on the EDURES project website, confirm the need to conduct classes based on the results of scientific research. Therefore, as part of the Intellectual Output O3 entitled *'Development of pilot lectures using EDURES methodologies'*, the EDURES project partners developed nine completely new lectures including, among others, the results of their scientific research. These lectures concern, among others: selected aspects of the cryogenic cooling on the milling process of products made of titanium (Figs. 8-10), coordinate measuring technique, surface roughness measurements and additive manufacturing. In the case of the lecture on the metrology of geometric quantities, attention was paid to, among others, on factors influencing the results of coordinate measurements and various methods of distributing measurement points on curvilinear surfaces of products that can be used in the automotive and

Fig. 8. The topic of one of the lectures prepared by the EDURES project partner – Furtwangen University

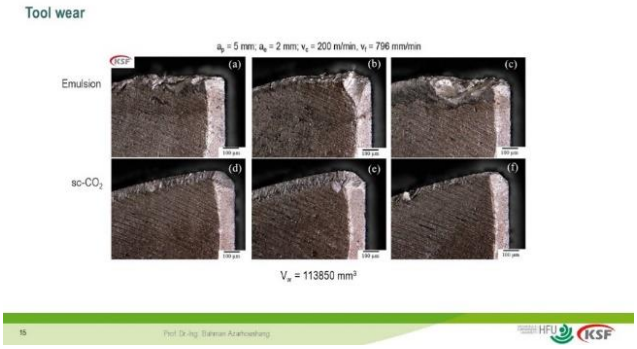

Fig. 9. Wear of cutting tools under cryogenic cooling compared with the conventional cooling (emulsion)

Fig. 10. Experimental setup of cryogenic milling of titanium

aviation industries. The lecture regarding coordinate metrology was based on the results of works published, among others, in articles (Magdziak Marek, 2019a; Magdziak Marek, 2019b).

The full list of the lectures developed, mainly regarding the manufacturing and quality control stages of a production process, is available on the EDURES project website and is as follows:

1. Productivity increase through spark erosion conditioned diamond/CBN grinding wheels.
2. Sc-CO2 Milling of Titanium.
3. Ultra-short pulse laser machining for creating profiles, textures, and functional surfaces.
4. Mechanical Properties of Composite Materials.
5. New Trends and technologies in additive manufacturing: theory application and modelling.
6. An Introduction to the Atomic Force Microscopy (AFM).
7. The use of computer aided technologies (CAx systems) in selected areas of technological research for manufacturing and civil engineering.
8. Comparison of conventional and modern CNC technologies.
9. Quality control and surface texture measurement.

6. E-learning courses including the results of scientific research

Based on the above lectures, which are the results of the Intellectual Output O3 of the EDURES project, the e-learning courses were developed as part of the Intellectual Output O4 entitled *'Digital platform with implemented EDURES teaching content'*. These courses were prepared by using the Moodle e-learning platform after analysis of e-learning platforms available for project partners. The figures 11 - 14 show parts of the course on e.g., coordinate metrology. The course includes four lessons, a database of videos and a forum that allows the exchange of opinions on the issues raised during the course. The films present the use of modern measuring systems and metrological software cooperating with them during, among others, measurements of free-form surfaces of products. The proposed elements of the coordinate measurement strategy can be used in industrial conditions to improve the accuracy of measurements and shorten the time of their implementation. The practical application of the information contained in the developed e-learning course is consistent with the conclusion drawn based on the analysis of the results of surveys conducted among entrepreneurs who are interested in the knowledge of their employees in the field of research results published in scientific journals.

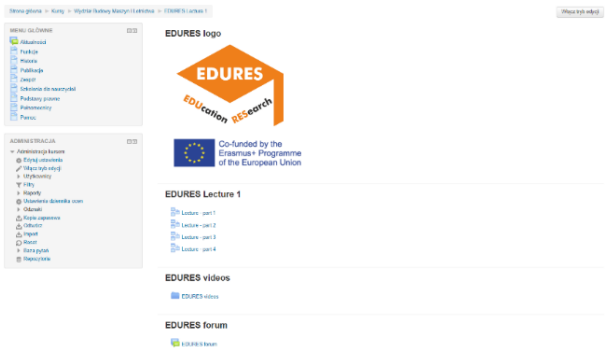

Fig. 11. The structure of one of the e-learning courses on the metrology of geometric quantities

Fig. 12. The fragment of one of the lessons of the developed course

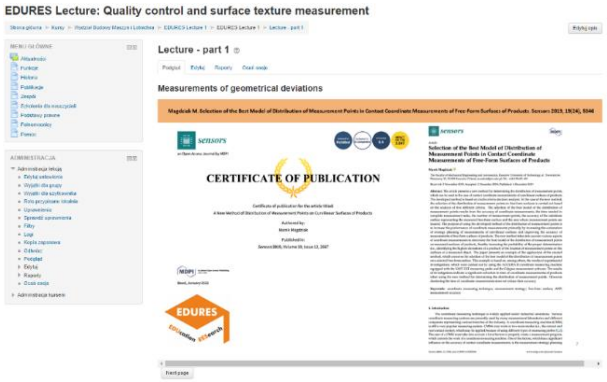

Fig. 13. The course is fully based on the results of scientific research

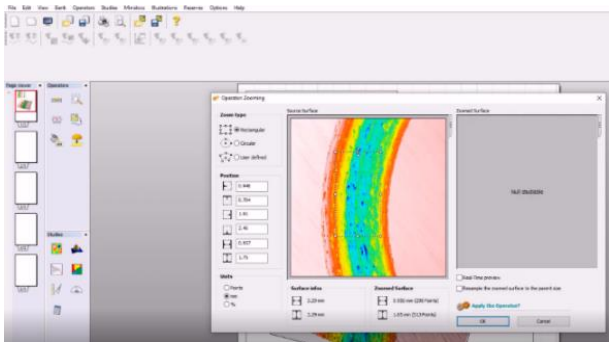

Fig. 14. One of the videos that are part of the e-learning course on surface roughness measurements

7. Research portal

As part of the Intellectual Output O2 entitled *'Development of the digital platform methodologies for utilization of research results in technology education'* of the EDURES project, survey research was conducted to develop the structure of a research portal enabling the popularization of research results. The figures 15-21 show selected results of research carried out at the Rzeszów University of Technology.

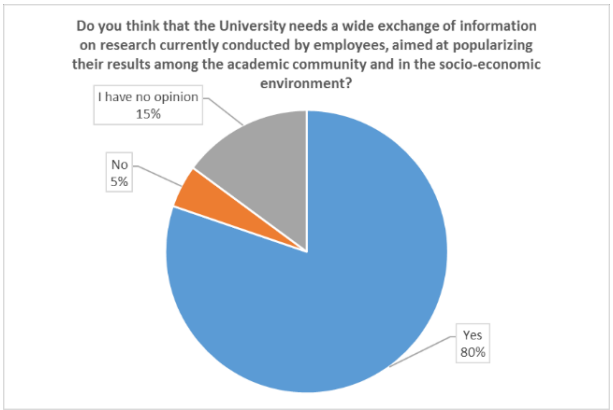

Fig. 15. Question: Do you think that the University needs a wide exchange of information on research currently conducted by employees, aimed at popularizing their results among the academic community and in the socio-economic environment?

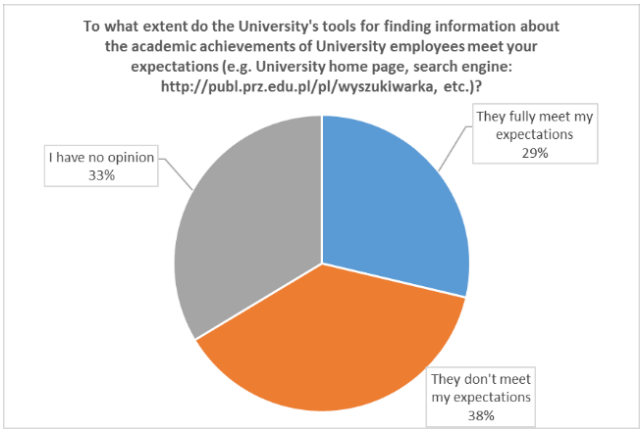

Fig. 16. Question: To what extent do the University's tools for finding information about the academic achievements of University employees meet your expectations (e.g. home page, search engine)?

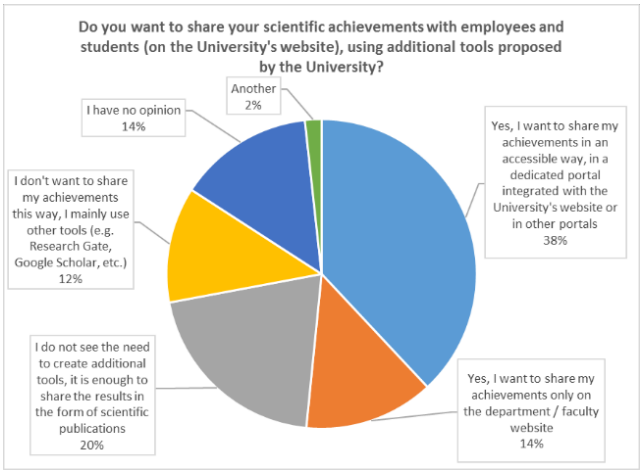

Fig. 17. Question: Do you want to share your scientific achievements with employees and students (on University's website), using additional tools proposed by the University?

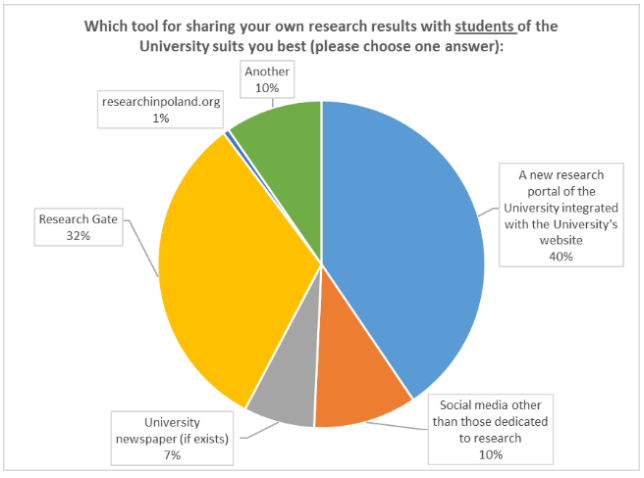

Fig. 18. Question: Which tool for sharing your own research results with students of the University suits you best (please choose one answer)?

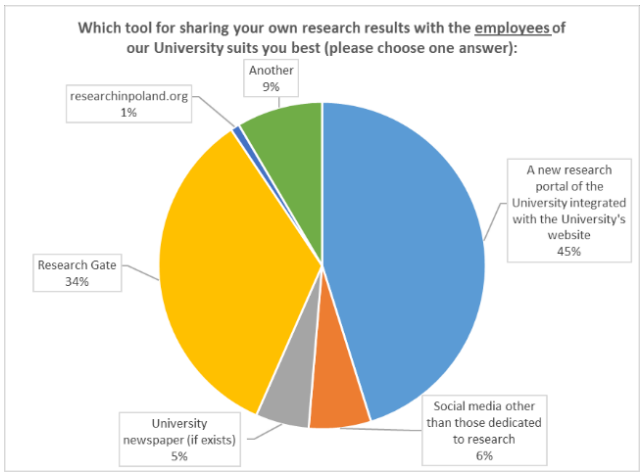

Fig. 19. Question: Which tool for sharing your own research results with the employees of your University suits you best (please choose one answer)?

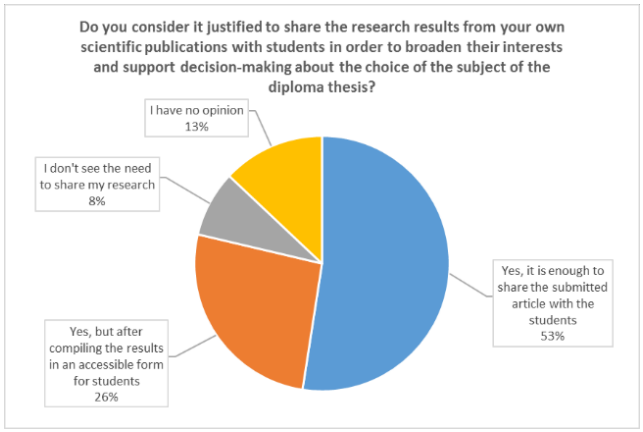

Fig. 20. Question: Do you consider it justified to share the research results from your own scientific publications with students in order to broaden their interests and support decision-making about the choice of the subject of the diploma thesis?

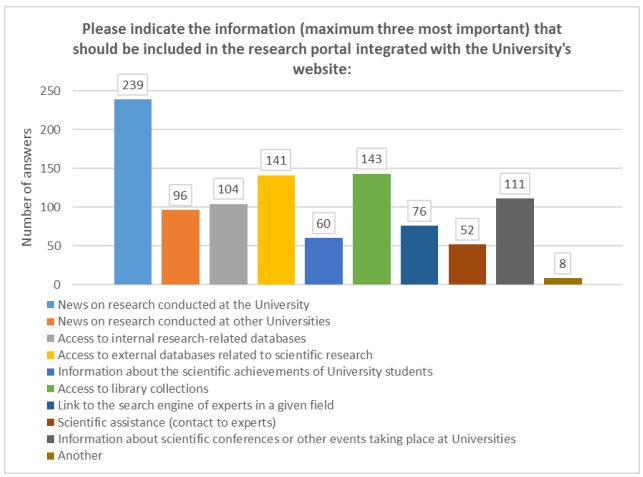

Fig. 21. Survey request: Please indicate the information (maximum three most important) that should be included in the research portal integrated with the University's website

Based on the analysis of the survey results, the following conclusions can be drawn:

1. Most of the respondents believe that it is necessary to exchange information on research conducted by university employees.
2. Most of the respondents are not satisfied with the tools that enable searching for information on scientific achievements of university employees.
3. Most employees of the Rzeszów University of Technology are willing to share their scientific achievements with students and other employees.
4. 40% of respondents want to share the results of their research with students via a research portal integrated with the university's website.
5. 45% of respondents want to share the results of their research with university employees via a research portal integrated with the university's website.
6. Most of the respondents believe that it is justified to share the results of their research with students to, among others, expanding their interests.

The results of the surveys clearly indicate the need to create a research portal enabling the sharing of research results with the academic community. Therefore, on their basis, the structure of the research portal was proposed, which includes the following elements:

1. News from scientific disciplines: this section concerns the latest news from the scientific disciplines which are run at the university.
2. Students' research: the section concerns the latest news from the scientific groups of students.
3. Scientific databases: the section should give an access to the scientific databases available at the university – mainly the databases shared by the university library.
4. Scientific help: the section gives an access to reference managers, software, manuals, and different instructions.
5. Perfect thesis: this part of the portal should give some instructions for students developing their theses at the university, including procedures, required documents, access to the topics, writing hints, etc.
6. Collaboration link: access to chat, forum, communication platforms.
7. Talk to professor: the direct access to communication tools enabling to discuss the scientific problems with professors and experts.

7. Conclusion

It has been proved that research-based education can have a significant impact on the entire teaching process in higher education institutions. Presented results of the surveys informed us that students of our universities pay attention to the interesting classes which are based on scientific achievements. The presented methodologies will help to organize the teaching process and increase the number of interesting presentations within lectures regarding the recent research results, number of scientific experiments, practical tasks in laboratories which form the modern skills of learners (e.g. skills which are based on the digital tools usage), etc. It can be also stated that the attention should be paid on the use of different digital platforms such as e-learning platforms or existing web portals for the aims of recent scientific achievements and knowledge transfer to the audiences. Especially platforms such as web portals play a crucial role for local stakeholders of knowledge who do not have direct access to the scientific databases and e-learning platforms. It shall be finally stated that it is worth implementing research results in teaching processes and universities should look for some solutions in this area. Selected tools such as: research-oriented work books for teachers, web portal methodologies, revision of e-learning platforms capabilities, lectures with implemented research results, smart web tools (e.g. thesis wizards) have been proposed by the EDURES partnership to be utilized and continuously developed in the future. The EDURES team has been presenting current project results which are the part of the paper on the project webpage placed (https://www.edures.prz.edu.pl 30.08.2023).

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