

# Postgraduate studies in the Institute of Information Technology of the Lodz University of Technology

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**Abstract.** *The article presents the assumptions, development path and key achievements of postgraduate studies at the Faculty of Technical Physics, Information Technology and Applied Mathematics of the Lodz University of Technology. The emphasis was placed on the role of cooperation with IT companies in developing postgraduate study programs related to the needs of the Lodz region as well as methods for assessing the quality of the learning process. In addition, problems related to changes in the labor market, as well as risks and opportunities resulting from the need to conduct classes differently during the COVID-19 pandemic, are discussed.*

**Keywords:** *postgraduate education, continuous education, social impact*

## 1. Introduction

The shortage of highly qualified specialists in the IT industry has been one of the main problems for years not only in Lodz, but also in the entire Polish labor market. At the same time, due to the economic and social changes taking place, many people do not see any prospects for further development in their professional career so they are looking for opportunities to gain other qualifications. Economic development requires a replenishment policy of human resources, especially for dynamically developing industries. In particular, the dynamic growth of the ICT industry sector that has been observed for many years makes it necessary to intensify recruitment processes in which companies acquire new employees. Furthermore, experienced specialists tend to change their workplace frequently,

which makes it difficult to maintain the required staff. In the case of companies located in the Lodz region, employees of IT departments often change employers after acquiring several years of experience and companies are constantly trying to attract new employees to their IT departments to replenish labor shortages.

In response to the demand of the labor market in the Lodz region, the Lodz University of Technology offers a wide range of study programs. The university's teaching offer also includes courses and postgraduate studies, where the training time is much shorter than in the case of traditional studies and is strongly oriented towards acquiring practical skills. In 2003, a dedicated offer of training courses in the field of the development and management of IT infrastructure built using GNU/Linux operating systems was prepared at the Faculty of Technical Physics, Information Technology and Applied Mathematics (FTIMS) [1]. The courses were based on a proprietary curriculum prepared by a team of experienced academic teachers of the Lodz University of Technology and their main goal was to provide students with the latest knowledge and practical skills. Each course offered a different thematic scope for creating, configuring and servicing particular elements of an IT infrastructure using the GNU/Linux operating systems. Classes were conducted using various distributions of the GNU/Linux operating systems, including CentOS, Fedora, etc. Although the prepared training courses were relatively independent of each other, course participants often decided to choose the entire set of courses. As a result of these positive experiences, it was decided to establish an extended training program in the form of postgraduate studies.

## **2. Postgraduate studies at the Faculty of Technical Physics, Information Technology and Applied Mathematics**

From the very beginning, the following assumptions were made regarding the postgraduate studies conducted by the Faculty of Technical Physics, Information Technology and Applied Mathematics:

- Education of highly qualified specialists in areas that are in great demand on the labor market and adapting the offer to changing needs of the ICT industry. Initially, in the period of the growing importance of Linux systems, the teaching offer was focused on educating specialists in the field of GNU/Linux systems and implementation of solutions based on them in corporate networks (postgraduate studies *GNU/Linux Systems Administration* [2]). Currently, the offer is aimed primarily at educating Java EE programmers, who are in great demand in the labour market (postgraduate studies *Modern Java/Jakarta EE Business Applications* [3]).

- The offer of postgraduate studies should be addressed both to people professionally related to IT or having IT education, whose expectations and requirements regarding the scope of the program and the acquired knowledge are very high, as well as to those who have no previous experience in a field of computer science and treat postgraduate studies as an opportunity for retraining. The implementation of this assumption in practice is very difficult and requires the development of curricula involving the systematic transfer of basic knowledge at an early stage of teaching, it also requires a lot of effort and motivation on the part of students.
- Prioritizing the quality of education and creating a learning environment to achieve this goal, including non-traditional forms of classes (lectures conducted in laboratories with the possibility of direct verification of the presented content on computer stands, presenting live application code development), classes conducted in small groups to ensure adequate teacher supervision, individual access to workstations, providing students with extensive and constantly updated teaching materials.

The current curricula and documentation of the postgraduate studies *GNU/Linux Systems Administration* and *Modern Java/Jakarta EE Business Applications* have been developed in compliance with the requirements of the National Qualifications Framework for Higher Education [4]. The learning outcomes were defined both at the level of the entire studies and individual subjects, as well as the corresponding verification methods. As in the case of other types of studies at the Lodz University of Technology, the ECTS system is used, and the number of points corresponding to individual subjects was assigned based on the workload necessary to achieve the intended learning outcomes.

## **2.1. The development of postgraduate studies in the field of IT infrastructure administration**

In 2007, the team of academic teachers from the Faculty of Technical Physics, Information Technology and Applied Mathematics prepared two-semester postgraduate studies *GNU/Linux Systems Administration*. The postgraduate curriculum included theoretical knowledge and practical skills in the field of operation, configuration and management of the GNU/Linux operating systems, computer networks, network services and other elements of complex IT infrastructures. Classes were scheduled on weekends to enable participation of working people interested in acquiring new professional qualifications. The classes were divided into 6-hour thematic blocks and were carried out in a room with individual computer stations. Despite the great interest in participating in postgraduate studies, the classes have been limited to 12 participants in order to ensure high quality education. For the

purposes of postgraduate studies, a dedicated computer lab was prepared in the former Division of Computer Networks. For each of the postgraduate students, a set of original scripts was prepared, covering all subjects included in the curriculum. In addition to textbooks, remote tests were prepared to verify the understanding of the issues discussed during the classes, consisting of multiple-choice questions. The first edition of postgraduate studies took place in the period from April 2008 to March 2009. Most of the students, after completing their postgraduate studies, started working in companies from the ICT sector. Even before the completion of the first edition of postgraduate studies, preparations for the next one have started. The changes included both updating and extending the thematic scope of postgraduate studies, and the program of one-year studies was divided into 4 subjects. In 2008/2009, the second edition of the postgraduate studies *GNU/Linux Systems Administration* was carried out for a group of 15 participants. In response to growing interest, in 2009, two editions of postgraduate studies were launched successively, each time for groups not exceeding 12 participants. As part of the preparation of each edition, the teaching material was updated and adapted to the progressive development of software and solutions used in the IT industry. Educational materials and online tests for postgraduate students were provided on the Moodle platform [5]. The tests were based on a random selection of multiple-choice questions, which allowed for better verification of knowledge. Postgraduate students also had the opportunity to monitor their progress, obtained grades and attendance logs. In addition, as a result of the reorganization of the structures of university units in mid-2009, the Division of Computer Networks was incorporated into the Institute of Information Technology [6], remaining in the structure of the FTIMS Faculty.

In the academic year 2010/2011, two editions of postgraduate studies were carried out as part of participation in the project *Postgraduate technical studies for entrepreneurs and employees of enterprises* (2.1.1 PO KL). In 2011/2012, the 7th edition of postgraduate studies *GNU/Linux Systems Administration* for a group of 14 students was conducted. For this edition, the e-learning infrastructure was based on the WIKAMP platform (Virtual Campus of the Lodz University of Technology) [7]. In the next (8th) edition, many changes were introduced, adapting the curriculum to new requirements.

In the case of our postgraduate studies emphasis was placed on monitoring the quality of education. In the second edition of postgraduate studies, electronic questionnaires were introduced, filled in anonymously by students on the WIKAMP platform for each of the subjects included in the postgraduate studies program. Electronic questionnaires facilitated the processing of questionnaire results, and their analysis allowed for systematic improvement of the quality of education. A part of such survey results view (in Polish) is depicted in Figure 1.

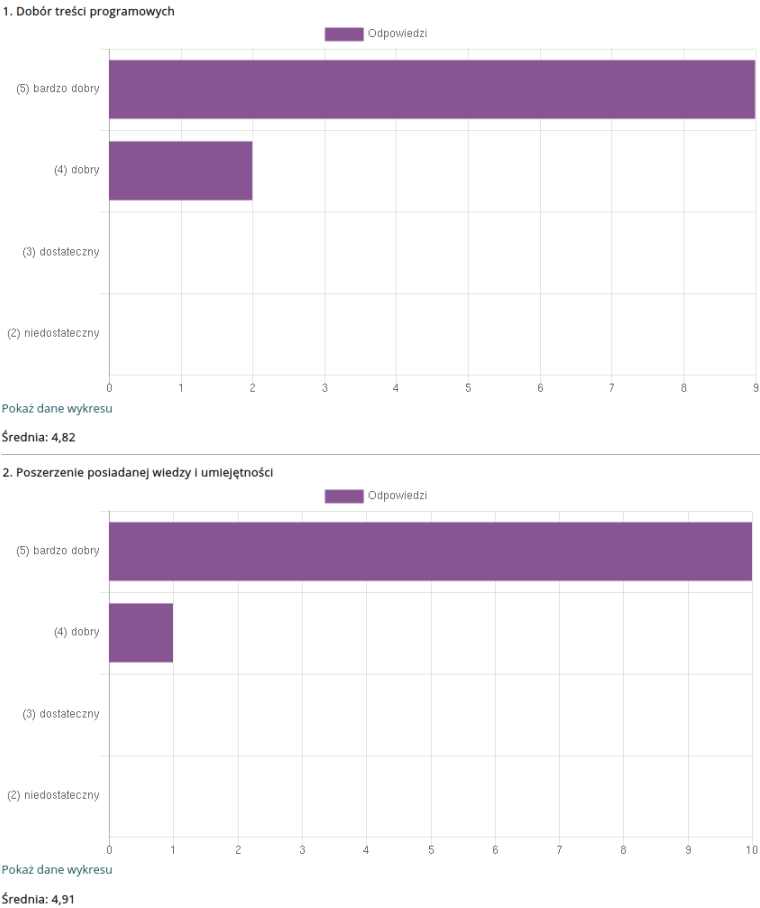


Figure 1. Partial results of a sample survey completed by participants of the 8th edition of postgraduate studies *GNU/Linux Systems Administration*

According to the new rules, students had to implement a final project. The curriculum content was also updated and divided into 8 subjects. These changes significantly improved the implementation of the teaching process. The curriculum developed for the 8th edition of postgraduate studies was updated for each subsequent edition. In the case of the 11th edition, conducted in the 2015/2016 academic year, the classes were moved to a more spacious room located in the so-called Building of Three Faculties (Lodex) on campus B of the Lodz University of Technology, which allowed to conduct classes in groups of up to 16 people.

In 2016, a new curriculum for postgraduate studies was prepared. Based on this curriculum, the 12th and 13th editions of postgraduate studies were conducted in the following years. The classes of the 13th edition were conducted in the modernly equipped Information Technology Center of Lodz University of Technology [8], which increased the quality of the teaching process.

Due to changes taking place on the labor market in the Lodz region, leading to a declining interest in learning operating systems and computer networks, with a simultaneous strong increase in interest in learning business application development, in 2018 postgraduate studies *GNU/Linux Systems Administration* were temporarily suspended and a decision was made to focus all efforts on the development of postgraduate studies *Modern Java/Jakarta EE Business Applications*.

## **2.2. The development of postgraduate studies in the field of creating multi-user systems and applications for business**

In 2011, in response to the local IT market demand for software developers, a new postgraduate course *Modern Java EE Business Applications* was prepared. The development of educational materials and methods of verification of knowledge and skills took about a year and, as a result, two-semester postgraduate study program was developed. The curriculum has been divided into 4 subjects and was aimed at preparing students to create business software using Java and a technological stack dedicated to software development for multi-access IT systems. The first edition of postgraduate studies *Modern Java EE Business Applications* was held in the 2011/2012 academic year. Due to the practical nature of postgraduate studies, the size of the group of students was limited to 12 participants. Classes of the first edition have been planned on Saturdays and Sundays to allow working people to participate in postgraduate studies. It was taken into account that some of the students were living outside Lodz, so on selected weekends two 6-hour classes were planned in a day-to-day pattern. In subsequent editions of postgraduate studies, the implementation of organizational improvements and e-learning methods gradually allowed to increase the size of the groups to 16 students while maintaining high quality of education. In the case of the second edition of postgraduate studies, which took place in the academic year 2012/2013, a new curriculum was

developed and introduced. The number of subjects was increased to eight and a final project was added in which students developed a business application and documented it in a report or final paper.

In the case of postgraduate studies *Modern Java EE Business Applications* the practice of monitoring the quality of education through the use of electronic questionnaires, filled in anonymously by students on the WIKAMP platform for each of the subjects included in the postgraduate studies program, was continued.

In 2018/2019, in response to the growing interest, two parallel editions of postgraduate studies (8th and 9th) were launched, in each of them the training was conducted in groups not exceeding 16 students. In the case of the 10th edition of postgraduate studies, which began in the academic year 2019/2021, there were additional difficulties in conducting classes resulting from restrictions introduced in Poland due to the global pandemic COVID-19 [9]. For a long time, the participants of the studies did not want to agree to the transition to distance learning, arguing that the quality of education that could be achieved in these conditions would not be adequate to their expectations and the price of postgraduate studies. However, due to the prolonged inability to conduct classes on the University's campus, studies were finally resumed in the remote mode. Remote learning was conducted using the MS Teams communicator and the WIKAMP platform. It turned out that in some respects the transition to the remote mode even had a positive effect on the effectiveness of the education process. Remote classes were recorded and made available to students using the MS Stream platform. The implementation of classes in a remote mode also allowed to save time associated with reaching the classes, which was especially important for students commuting from outside Lodz. On the other hand, the change to remote mode happened unexpectedly and not all students were prepared for it, also in technical terms (appropriate equipment, place of study, Internet access). These experiences were used to prepare and launch the next, 11th edition of postgraduate studies. From the very beginning, this edition was launched in a hybrid mode and it was included in the contracts signed with candidates for studies. It seems that the hybrid mode, depending on the current epidemic situation and the resulting orders of the University Authorities, is the most optimal in the current conditions.

### **3. Teaching methods at postgraduate studies**

From the very beginning, the teaching process at postgraduate studies was based mainly on workshop classes, so the traditional university teaching organization based on the division into separate lectures and laboratory classes was abandoned. Lectures (presentations) were conducted directly in appropriately adapted

laboratory rooms, which ensured a large interaction between the teacher and students. It was possible due to conducting training in relatively small groups not exceeding 16 students.

In the case of studies in the field of application development for business, the method of live coding was used. It requires a very careful preparation of all parts of a lecture, but ensures high teaching effectiveness and is very well received and assessed by students. It also provides students with the possibility of direct verification of the presented lecture content on their computer workstations.

Also from the very beginning, the teaching infrastructure of postgraduate studies was based on the Moodle e-learning platform [5] (currently it is the WIKAMP platform managed by the University's IT Center [7]). This platform made it possible to create an integrated e-learning environment in which teaching materials, knowledge verification tests (both partial and final tests) and discussion forums, ensuring effective communication between students and lecturers, were made available remotely. The partial tests were used to assess the level of understanding on an ongoing basis after the end of each class (formative assessment). The summary (final) tests were used at the end of each subject block to verify the acquired knowledge (summative assessment).

Educational materials developed and delivered to students play a very important role in the teaching process. They were particularly extensive in the case of postgraduate studies of *GNU/Linux Systems Administration* (this was due to the lack of sufficiently comprehensive and up-to-date textbooks on the publishing market). These materials were constantly updated to the latest versions of systems and standards. In the final reports of the project *Postgraduate Technical Studies for Entrepreneurs and Employees of Enterprises* they were recognized as the best (ex aequo) out of the 32 postgraduate courses assessed [10, 11].

## 4. Cooperation with Central Poland ICT Cluster

Central Poland ICT Cluster is a forum for cooperation between companies from the IT, telecommunications and electronic industries, established on the initiative of the Lodz University of Technology, aimed at integrating this environment, supporting entrepreneurship and developing the labor market in the field of ICT (*Information and Communications Technology*), as well as creating conditions for the implementation of new technology, and the development and training of staff for the ICT industry [12].

One of the goals of the Cluster is cooperation with academic centers focused on developing modern education courses adapted to the needs of the labor market. One of the elements of this activity is the evaluation of curricula and teaching



methods for postgraduate studies and awarding the best of them with the Cluster recommendation.

As part of cooperation with Central Poland ICT Cluster, the curricula of postgraduate studies *GNU/Linux Systems Administration* and *Modern Java/Jakarta EE Business Applications* were consulted with companies associated in the Cluster in order to adapt them to the needs of potential employers. Moreover, postgraduate studies were hospitalized by representatives of the Cluster. The result of this cooperation were recommendations for our postgraduate studies [13, 14, 15].

### 5. Quality of education at postgraduate studies

From the very beginning, the highest priority in creating postgraduate studies was to ensure high quality of education. One of the elements of quality control of education at postgraduate studies at the Lodz University of Technology is the survey conducted on the basis of the applicable template of the *University didactic survey of postgraduate studies*. In this questionnaire, students evaluate the curriculum content, the method of conducting classes, the organization of classes, teaching materials and other elements influencing the quality of education. As an example, the statistical results in three key aspects of the postgraduate curriculum evaluation are presented separately for each of the fields.

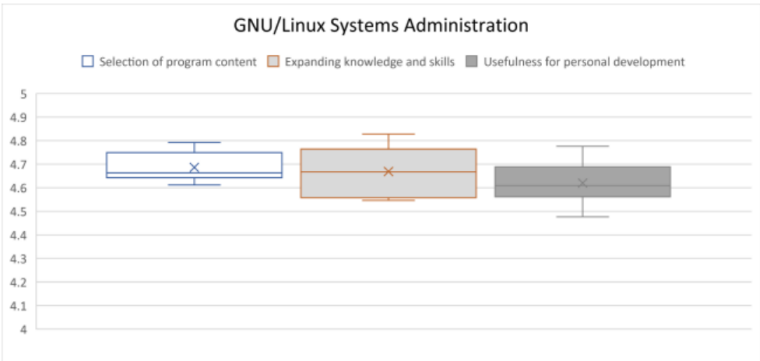


Figure 2. Evaluation results for *GNU/Linux Systems Administration* curriculum

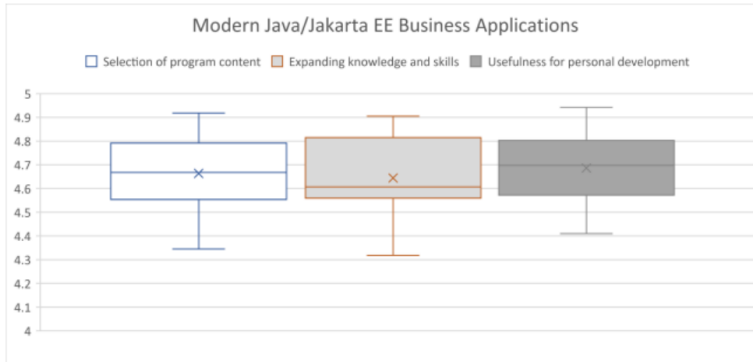


Figure 3. Evaluation results for *Modern Java/Jakarta EE Business Applications* curriculum

The grades obtained over the years were usually very good even though the expectations of postgraduate students were always very high. Note that none of the grades is below 4.3, and none of the medians and means is below 4.6, on a scale of 2 to 5. On the other hand, the postgraduate curriculum is very extensive, and the pace of its implementation is high. This is a big challenge for people who have no previous programming skills – therefore the grades obtained in the questionnaires were generally higher for students with some previous experience in the field. The high variation in the level of previous experience of *Modern Java/Jakarta EE Business Applications* participants is reflected in the clearly greater variability of their grades, visible both in the range of the minimum and maximum values, and in the span of the first and third quartiles of results.

The high level of satisfaction of postgraduates can also be inferred from their directly expressed opinions. Some of the postgraduates agreed to have their opinions and recommendations published [2, 3, 16, 17].

Extensive curricula focused on acquiring skills sought in the labor market and prioritizing the quality of education were appreciated not only in the assessments of students included in university didactic questionnaires or in direct assessments expressed by graduates. An unique opportunity for a more systematic assessment of the quality of education at our postgraduate studies compared to other postgraduate studies was the participation the postgraduate studies *GNU/Linux Systems Administration* in the *Postgraduate technical studies for entrepreneurs and employees of enterprises project* (2.1.1 PO KL) implemented in 2010-2011 in cooperation between the Lodz University of Technology and the Wroclaw University of Technology. In independent external final reports prepared at the end of this project, out of 32 assessed postgraduate courses offered by both universities, the postgraduate studies *GNU/Linux Systems Administration* were recognized as one of the best, in

particular taking first place *ex aequo* in the category of "lecturers" (score 4.81) and second place in the "content of classes" category (grade 4.61) [10, 11].

In 2021, the team developing postgraduate studies was awarded the prestigious Award of the City of Lodz for outstanding achievements and contributions to the development of our City [18]. This honorable distinction summed up the many years of developing postgraduate studies and other forms of education in cooperation with ICT companies from the Lodz region [19, 20].



Figure 4. Meeting at the Lodz City Hall, from the left: Michał Karbowańczyk, Marcin Kwapisz, Roman Krasiukianis, chairman of the City Council of Lodz Marcin Gołaszewski, Mateusz Smoliński (June 9, 2021). Photo: Jacek Szabela

## 6. Summary

High-quality education is one of the most important conditions for the development of modern societies. This statement particularly applies to the Lodz region. Lodz, once seen as the city of factory chimneys and the textile industry, has undergone a profound transformation over the past years and it is now a modern academic center and home to many IT industry companies.

Postgraduate studies, although often underestimated, can play an important role in the process of educating human resources for the needs of the new economy and the emerging information society. However, for this to be possible, close cooperation between the university and its economic environment is necessary. In order to fulfill their role, postgraduate curricula should be constantly adapted to new needs resulting from changes in technology. Moreover, potential employers,

in this case companies from the IT industry, should be involved in the entire education process, in particular by evaluating curricula and assessing the methods of conducting classes.

Regardless of its role in economic development, postgraduate studies can also play an important social role, offering a chance for a better future to those who, in the period of rapid changes, try to obtain new professional qualifications and find themselves in a new reality. Our experience also shows that specialized education in groups of people with a very different level of initial preparation is possible, however it requires a lot of effort on the part of both the staff and those students who have little experience in the field of IT.

## Acknowledgements

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