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Research article

Advancing geodesy education: Innovative pedagogical approaches and integration into STEM curricula

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Abstract: In an increasingly interconnected world, integrating geodesy into STEM education is vital for a comprehensive understanding of Earth's spatial dynamics. This research aims to analyze contemporary pedagogical approaches in geodesy and explore the integration of advanced land surveying methods into Kosovo's educational framework. By addressing gaps in current geodesy education, the study emphasizes the importance of developing robust geospatial skills to tackle global challenges and promote sustainable development. By examining case studies and international best practices, the research presents a blueprint for designing an inclusive, dynamic curriculum that deepens a students' understanding of geospatial concepts while fostering scientific inquiry and critical thinking. The findings highlight the transformative potential of incorporating geodesy into STEM education, thereby enhancing spatial literacy and equipping students to address complex global issues through evidence-based decision-making and innovative problem-solving. Additionally, the research details the evolution of Kosovo's Department of Geodesy, noting improvements in the program accreditation, curriculum adjustments in response to labor market needs, and benefits from European Union projects. This paper concludes with actionable recommendations for policymakers, educators, and stakeholders to effectively integrate modern geodesy pedagogies into Kosovo's educational system. This integration is essential to foster a sustainable framework for the holistic development of students and to contribute to a broader societal progress.

Keywords: geodetic skills, sustainable development, curriculum design, spatial dynamics, global

challenges

1. Introduction

The education system of Geodesy in Kosovo is undergoing significant changes due to the processes of globalization and societal integration, as well as transformations in the socio-economic sphere. This necessitates a shift towards a more targeted approach, thereby focusing on the professional training of capable and intellectually advanced specialists who can lead and innovate. These professionals should possess the skills for professional development, self-improvement, and creative problem-solving in the complex field of geodesy and cartography. In order to promote the development of individuals who possess a contemporary perspective and mindset, the goal is to nurture individuals who are well-prepared for professional opportunities in the fields of land management, topographic-geodetic and cartographic activities, state cadastres, geoinformation systems, and territorial planning. All of this is crucial given the rapid development of the industry, the competitive nature of the land market, and the increasing demands from society for effective land resource management [1]. The education system of Geodesy in Kosovo must address local needs such as effective land use planning, environmental management, and disaster preparedness. These areas are critical to ensure sustainable development and address the specific challenges faced by the region. By aligning geodesy education with these priorities, the system can produce specialists capable of applying geodetic and cartographic expertise to support informed decision-making and resource management.

The formation of highly qualified specialists who possess a complex of theoretical knowledge and practical experience of professional activity is the goal of the modern university educational process. The successful implementation of professional activities requires the development of personal qualities and practical skills of future specialists, which is why the demand for practical-oriented education is on the rise. The unity of theory and practice becomes the foundation of significant professional and personal competencies, as well as professional culture in general. To ensure the practical component of activity in the educational and professional program of Geodesy, it is crucial to implement modifications at the methodical, content, and organizational levels of training for students in higher education. These changes should aim to preserve the traditional, scientifically grounded approaches of the program organization while also providing modern approaches to cultivate professionally adaptable specialists [2]. In order to effectively address the challenges of everyday practice, it is crucial for future surveyors to possess the skills to freely navigate in a constantly changing professional environment. This entails developing the ability to autonomously determine goals, content, methods, and means of professional activities. Furthermore, it is essential to acquire techniques for self-discovery, self-analysis, and self-evaluation. Additionally, future surveyors must learn to activate the processes of self-improvement and self-creation of their own identity. In other words, they need to cultivate the readiness to be adaptable and competent in diverse professional circumstances [3].

For researchers, several challenges might be encountered when investigating pedagogical approaches in modern geodesy and the integration of earth measurement techniques into STEM education in Kosovo. These challenges can be considered as problematic aspects and may include a limited research infrastructure as an access to an advanced research infrastructure and technology for conducting experiments and measurements in the field of geodesy and earth sciences, thus hindering the scope and depth of research investigations. Additionally, there is a problem of data accessibility and quality. Obtaining reliable and high-quality data for research purposes might be challenging, especially in the context of geodesy and earth measurement techniques. Ensuring the availability of accurate and up-to-date data could be a significant obstacle. Additionally, the lack of funding and resources is a typical challenge for researchers in this field. Insufficient financial resources and opportunities to fund research initiatives in the field of geodesy and STEM education can hinder the implementation of comprehensive research projects and the implementation of innovative teaching methods.

The Department of Geodesy, which is part of the Faculty of Civil Engineering, is the only institution of higher education in Kosovo, which was founded in 2003, where one can study geodesy and geoinformatics within the bachelor's and master's programs. Bachelor's studies in Geodesy entail a 3-year study program, while those in the master's entail a 2-year study program, according to the Bologna system. It is known that the Bologna system in Kosovo has been applied since the academic year 2001/2002 [4]. After a period of several years, the Department of Geodesy started the master's studies in the academic year 2015/16 as part of the Tempus Project Master's Program in Geodesy (MPG). The main purpose of these programs is to produce staff who respond to the labor market both within the country and abroad. The problems of the development of Geodesy teaching in Kosovo have been studied in the works of several scientists. In their study, Sylka et al. [5] considered the peculiarities of the curriculum at the Department of Geodesy at the University of Prishtina; however, they did not touch on the problems of pedagogical approaches in the educational process. Retscher et al. [6] focused on pedagogical approaches in the study of Geomatics, especially in the context of the COVID-19 pandemic and the forced mode of distance learning.

Chuanyi et al. [7] considered the main methods (Monte Carlo, Scaled unscented transformation, Sterling interpolation and Spherical cubature rule) of the non-linear error propagation in their work. They based their research on several artificial experiments and considered it useful for further applications in Geomatics. Bedair et al. [8] investigated the influence and possibilities of modern technologies on pedagogical approaches in geosciences in the conditions of the COVID-19 pandemic and the post-COVID era. Kumar et al. [9] assessed the state of development of technologies used by geoscientists in practice. Kiani [10] investigated the state of interpolation methods in Geodesy and analyzed the possibilities of improving research methods in geoscience.

Recently, an increased tendency of European countries to absorb more and more cadres from different fields, especially in the fields of construction, geodesy, has been observed. Therefore, geodesy and geoinformatics are increasingly being used today in many different sciences such as computer science, engineering, construction, architecture, environment, hydromechanics, geology, and archaeology. In the work market, it has always been easy for graduate engineers of geodesy to find employment. The current situation suggests that all 40 engineers who graduate each year are able to quickly secure a job. The teaching process has been greatly influenced by scientific work, thus leading to the introduction of new knowledge and concepts. The Department of Geodesy has made several significant changes to its curricula over the years. Thus far, a total of six bachelor's curricula and three master's curricula have been modified. These changes have mostly been influenced by the university's curricula from Central and Western Europe (Austria, Germany, Switzerland) [9]. One of the reasons many of the students graduated in bachelor's and master's studies in Prishtina found jobs was the availability of positions in the countries of the European Union.

While existing studies have explored various aspects of geodesy education, there remains a gap in addressing the integration of contemporary pedagogical approaches within the context of Kosovo's higher education system. This paper aims to fill this gap by investigating how innovative teaching methods, industry collaboration, and technological integration can enhance geodesy education. The research objectives include evaluating current training practices, identifying areas for improvement, and proposing actionable strategies to modernize the curriculum to better prepare students for the evolving demands of the geodesy profession.

2. Literature review

Research publications on pedagogical approaches in modern geodesy and the integration of land surveying methods in STEM education in Kosovo are quite numerous and focus on the intersection of geospatial technologies and educational practices.

Sicuaio et al. [1] connected practice-oriented learning with the use of the concept of contextual learning. However, the practical component of the professional training for future specialists in the field of Geodesy, which is a program that integrates both knowledge and practice-oriented principles, has been insufficiently researched. It was established that the solution to the specified scientific problem is based on the following: revealing the importance of education in the system of human activity, according to Arun [2]; taking the quality of professional training in accordance with the social needs and expectations of service users into account, according to Kravchenko and Bullock [3]; and the disclosure of aspects of formation of professional competence of specialists in Kosovo and other countries, according to Ledoux and Gold [4]. As Retscher et al. [6] claimed, professionally oriented learning technologies play a decisive role in the formation of socially significant personality traits, knowledge, abilities, and skills necessary for conscious professional self-determination in students of higher education. Bedair et al. [8] investigated the problem of solving organizational tasks and conducting educational practices in the process of professional training.

The consideration of educational needs and the personal potential of future specialists in planning the trajectory of professional development was studied by Robinson and Metternicht [11]. Goudarzi et al. [12] conducted an analysis of the peculiarities of the organization and conducting production practices. Roberts and Harvey [13] associated practice-oriented education with professionally oriented learning technologies. These technologies are implemented through the organization of practices that aim to familiarize students with the professional environment and emphasize the importance of social partnership among state bodies, employers, and the public. This combination aims to maintain the fundamentality of higher education while also accumulating a practical experience and shaping competent and mobile professionals. Ercan et al. [14] investigated the possibilities of involving the Geographic Information System in the study of STEM Education disciplines. Burkholder [15] compared the experience of using different geospatial data measurement models.

The integration of geodesy into STEM education is enhanced by interdisciplinary approaches and the use of technology. Fedoniuk et al. [16] highlighted the role of Information and Communication Technology in geoscience extracurricular activities, thereby improving a students' problem-solving skills and understanding of geospatial concepts. Jeong and González-Gómez [17] discussed the application of web-based tools to optimize decision-making in renewable energy, thus emphasizing the real-world relevance of STEM education in geodesy. Manning and LaDue [18] presented a framework for Geo-STEM learning ecosystems, which promoted community engagement and collaborative problem-solving. Gilbertz et al. [19] showed that integrating sustainability into STEM curricula improved student critical thinking and comprehension. These studies underscore the value of technology, collaboration, and sustainability in advancing geodesy education to meet the industry demands and global challenges.

These works collectively explore the implementation of contemporary geodesy methods, such as the Global Navigation Satellite System (GNSS), remote sensing, and the Geographic Information System (GIS), within the context of educational frameworks, thus emphasizing their applications in fostering critical thinking, problem-solving, and spatial reasoning skills among students in Kosovo. Additionally, they highlight the significance of adapting pedagogical strategies to accommodate the unique educational landscape of Kosovo, ultimately paving the way for a more integrated and comprehensive approach to geospatial education within the broader STEM curriculum.

3. Materials and methods

In order to understand the system, main indicators, and conditions for the implementation of higher geodesical education in Kosovo, an analysis of the regulatory and legal documents (such as "Geodesy (Msc) Program Re-Accreditation: Report of the Expert Team" [20]) of the Department of Geodesy at the University of Prishtina in the field of higher education was performed. The analysis of the state policy in the field of the development of higher professional education and higher educational institutions until 2023 was performed on the basis of research documents. The prospects of the popularity indicators in the context of the process of the strategic development of the Department of Geodesy were studied on the basis of the official information from the University of Prishtina.

The research employed a comprehensive methodological approach to evaluate the development and functioning of the Turkic languages within the context of socio-cultural and structural changes. Initially, the study focused on collecting a wide range of primary and secondary data sources, including historical, political, and linguistic records, as well as contemporary surveys and interviews with experts in Turkic linguistics. The primary research method involved historical and political analyses to trace the evolution of Turkic languages, with a particular emphasis on how socio-cultural changes have influenced their use and development over time.

In addition to the historical analysis, the study utilized classification techniques to organize the different linguistic and cultural features observed within the Turkic-speaking regions, thereby examining the role of these languages in shaping social structures and regional identities. To support the analysis, statistical data was collected regarding the language usage patterns, demographics, and socio-economic indicators in Turkic-speaking regions. This data was analyzed using both descriptive and inferential statistical methods, which allowed for a detailed understanding of the socio-cultural dynamics at play. Furthermore, the research incorporated forecasting and comparative methods to project future developments in the region's linguistic landscape. This involved evaluating trends in language use, migration, and demographic changes, as well as comparing these trends to those observed in other regions with similar socio-cultural characteristics. Additionally, the study employed a political and legal analysis to understand how the policies of various states influenced the development of Turkic languages, particularly in relation to statehood, education, and cultural preservation initiatives.

The methodological approach ensured a holistic view of the challenges and opportunities Turkic languages face in the context of rapid socio-cultural transformations, thus offering a nuanced understanding of the intricate relationship between language, identity, and cultural change. This multi-method approach facilitated the identification of both historical and contemporary factors that shape the development of Turkic languages, thus providing valuable insights into their future trajectory within the broader geopolitical and cultural context.

4. Results and discussion

4.1. Contemporary pedagogical approaches in geodesy education

As a field of study that deals with the measurement and representation of the Earth, geodesy has seen significant advancements in technology and methodologies over the past few decades. Consequently, pedagogical approaches in geodesy education have evolved to incorporate these changes, reflecting both the growth of the discipline and the shifting demands of the global workforce. This section explores the current pedagogical trends in geodesy education, thereby highlighting the integration of modern technologies, interdisciplinary learning, and the importance of practical skills.

One of the most significant shifts in geodesy education is the integration of modern technologies into the curriculum. Traditional geodesy, which is based on manual measurements and physical instruments, has been replaced or supplemented with advanced tools such as GIS, remote sensing, GNSS, and Light Detection and Ranging (LiDAR). The growing role of these technologies necessitates a pedagogical shift that emphasizes digital literacy, data analysis, and software proficiency. Educators are increasingly incorporating software training into their courses, which enables students to not only understand theoretical concepts but also to work with the tools that define contemporary geodesy. Students are introduced to advanced data processing techniques, geospatial data visualization, and spatial analyses, all of which require a high level of technical expertise. This approach ensures that the graduates are well-prepared for careers in industries such as surveying, urban planning, environmental monitoring, and infrastructure development, where the ability to use cutting-edge geospatial tools is crucial.

In response to the complexity and interdisciplinary nature of geodesy, there has been a strong move towards problem-based and project-based learning (PBL) approaches in geodesy education. PBL encourages students to work on real-world problems, developing not only their technical skills but also their critical thinking, problem-solving, and teamwork abilities. For example, students might work on a project to design a geodetic network for a new urban area, requiring them to integrate principles of geodesy with environmental science, infrastructure planning, and public policy. This approach is particularly effective in fostering a deeper understanding of the practical applications of geodesy, while also allowing students to experience the interdisciplinary nature of modern geospatial challenges.

Geodesy is inherently interdisciplinary, intersecting with fields such as geography, engineering, physics, and environmental science. As a result, modern geodesy education increasingly emphasizes interdisciplinary learning. Students are encouraged to study not only the core geodesy topics, but also related subjects such as cartography, environmental science, and civil engineering, which are integral to the application of geodetic principles in various contexts. The introduction of interdisciplinary courses and collaborative projects with other departments enables students to gain a broader understanding of the geospatial landscape and its connection to real-world issues. This approach prepares graduates to tackle complex, multi-faceted problems in sectors such as urban development, disaster management, and climate change, where a geospatial perspective is crucial.

With the increasing mobility of students and professionals across borders, geodesy education has become more globalized. Many educational institutions now offer joint degree programs, online courses, and international exchanges that allow students to gain exposure to different geodetic practices and standards across the world. This globalization of education helps students understand the regional variations in geodesy, including the different methods used for geodetic measurements, data collection, and analyses. Additionally, the globalization of geodesy education reflects the growing international collaboration in geospatial data collection and analyses, particularly in the fields of climate monitoring, disaster relief, and sustainable development. As a result, geodesy students are trained not only to work with local data, but also to interpret and analyze global datasets, thus preparing them for careers in international organizations, research institutes, and multinational companies.

While theoretical knowledge remains important, contemporary geodesy education increasingly emphasizes the development of practical skills. Many universities now incorporate internships, fieldwork, and collaborations with industry partners into their programs. These opportunities allow students to apply their classroom knowledge to real-world projects, thus gaining hands-on experience with geodetic equipment, software, and methodologies. Additionally, industry collaboration ensures that the curriculum is aligned with the current market needs. By working with professional organizations, educators can ensure that students are familiar with the latest developments in the field and are equipped with the skills that are in demand by their employers. Additionally, the involvement of industry professionals in teaching and mentorship provides students with valuable insights into the day-to-day practices of the geodesy profession.

Experiential learning plays a crucial role in geodesy education, as it bridges the gap between theoretical knowledge and real-world application. As a field that requires the precise measurement and analysis of spatial data, geodesy demands not only a strong theoretical foundation, but also practical skills in handling sophisticated instruments, interpreting data, and applying geospatial knowledge in various contexts. By engaging students in hands-on activities such as field surveys, the use of geodetic equipment, and real-world problem-solving scenarios, experiential learning fosters critical thinking, enhances their technical proficiency, and prepares students to tackle complex challenges they will face in the workforce. Moreover, experiential methods help students develop a deeper understanding of abstract concepts, such as coordinate systems and spatial analysis, by directly applying them in tangible situations. Additionally, this approach fosters collaboration and communication skills, which are essential for future geodesy professionals working in interdisciplinary teams. Through experiential learning, students gain confidence in their abilities, experience the practical implications of their studies, and are better equipped to contribute to industry advancements upon graduation. Thus, integrating experiential learning into geodesy education is essential to produce well-rounded, industry-ready professionals capable of addressing the evolving demands of the field.

With growing concerns about climate change, environmental degradation, and sustainable development, there has been an increased focus on the role of geodesy in addressing these global challenges. Contemporary geodesy education places a strong emphasis on sustainability, thereby encouraging students to consider the environmental impact of their work and the ethical implications of geospatial data collection and use. Students are taught not only the technical aspects of geodesy, but also the importance of using geospatial data responsibly, particularly in relation to privacy concerns, data sharing, and the potential for misuse. The integration of ethical considerations into the curriculum ensures that future geodesists are equipped to navigate the complex social, environmental, and political implications of their work.

4.2. Development of the department of geodesy at faculty of civil engineering

In Kosovo, constant monitoring and assessments play a crucial role in the field of information technology-assisted teaching and learning, which is a relatively new concept. Similar to any other endeavor that combines pedagogical activities with technological advancements, it requires a continuous optimization process. In the modern era, the practical component of training future specialists must undergo significant transformations [21]. These transformations are necessary to cultivate various essential qualities in individuals. These qualities include the development of personal activities, which fosters a strong and enduring motivation to engage in activities and to explore new forms and types of activities. Additionally, it is crucial to instill the ability to adapt flexibly to the ever-changing conditions of professional life in individuals. Furthermore, creativity and a creative approach to organizing one's own activities should be encouraged, with the aim of purposefully and expediently transforming them. Finally, individuals should possess the capacity for continuous self-development and self-education. Given the context of technological progress, the mentor's role is emphasized in the professional integration of newly qualified teachers into the academic field. Being constantly confronted with challenges that arise from the advancement of pedagogical methods, the mentor must be open to embracing novelty and discerning which methods and technologies to leverage and to rely on. The meetings between the novice and mentor prove highly beneficial, as they provide valuable suggestions and insights. The mentor's extensive experience in both the specialty domain and teaching allows for the easy integration and implementation of their observations.

The complex educational practice, which includes the study of fundamental professional disciplines such as geology and theory of geosystems, topography, and cartography, plays a significant role in the crystallization and optimization of future specializations in the educational process. A practical consolidation of theoretical knowledge is essential in this practice, as it allows future specialists to acquire basic practical skills in working with analogue geodetic devices and performing field geodetic work [7]. Moreover, the applicants learn about the methods and rules of using maps to solve scientific and practical professional problems, which adds a unique feature to this practice. The complex mastery of geodetic methods to solve various applied tasks is the peculiarity of educational practice in geodesy for future specialists, which serves as the foundation for successful geodetic provision of works in land management and construction for future professional activities [22]. It involves the implementation of the main principles of work and structures the process of task performance in the context of modern conditions, thereby utilizing the necessary devices and techniques. Additionally, it provides an opportunity to acquaint oneself with the work of new geodetic equipment in production conditions [8].

During the industrial practice, applicants are prepared for the execution of land management tasks, which holds a significant position in the process. An essential aspect is the adherence to fundamental principles while studying, evaluating, and analyzing work tools and materials in practical sessions. This includes the establishment of boundaries on the land, geodetic surveying, and the adjustment of land use and ownership plans. Additionally, the practical classes focus on acquiring skills in performing land management and cadastral work, such as accounting for the quantity and quality of land, the monetary valuation of land plots, state registration, and allocation processes [23]. The acquisition of primary experiences in professional activities is a prominent aspect of this practice. The practice of future geodesy specialists primarily focuses on the formation of integrated knowledge obtained while studying various disciplines in the professional field. Additionally, it emphasizes the development of skills for independent research and the cultivation of personal and professional competencies necessary to solve applied problems in the fields of land management, geodesy, and geoinformatics [9]. Additionally, it prepares individuals for their qualification work.

The ability to use an analytical approach when justifying a decision affects non-standard thinking, the ability to correctly assess the overall task, and the effectiveness of using variant designs [24]. The quality of information support for future qualification work in accordance with the chosen research topic and competence coordination with by ordering a specialist is also influenced by the ability to concisely present and defend one's point of view with arguments. This is a feature of this practice. Developing and consolidating theoretical knowledge, using them in practice, and developing the need for self-education are among the primary objectives of educational practices [25]. Additionally, it focuses on cultivating the professional qualities of future specialists, fostering professional skills and abilities, examining work experience, and enhancing the capacity for carrying out professional activities [26,27]. Furthermore, an active involvement in scientific and research work is encouraged, along with the cultivation of a creative approach to problem-solving.

The training of future specialists in the field of Geodesy and land management incorporates several didactic principles. These principles include the integration of theory and practice, the systematic and progressive development of professional skills and abilities, the alignment with future professional activities, the emphasis on practical training, the gradual increase in independence and responsibility in professional tasks, and a focus on the developmental aspect of practical training [12]. In accordance with contemporary scientific perspectives, professional activities are understood as the demonstration of an individual's essential qualities and attributes within a specific profession, that is, within the social and professional conditions in which the individual operates. The adaptability of a future specialist's personality is considered to be the capacity to effectively adjust to the constantly changing conditions of professional activities.

In the practical training of future surveyors, there is a task that focuses on the development of adaptability skills in the professional environment [28]. This task requires students to analyze their professional direction, scientific interests, and personal preferences and come up with conclusions and proposals to improve a specific aspect of the enterprise's work. The enterprise in question specializes in topographical and geodetic works. By completing this task, the students acquire various abilities such as the ability to make effective decisions based on given conditions, solve professional problems, and apply their knowledge, skills, and abilities in a flexible manner. In the process of industrial internships, the applicants from higher education institutions typically adopt a conventional approach to organizing their experience. This approach primarily consists of working in groups and relying on explanatory methods to transfer information [29]. The educational process is managed in a demarcated manner, with future specialists mostly playing a passive role. However, it is essential for them to overcome uncertainty and learn how to react to specific situations that arise. Moreover, they must acquire personal experiences and adapt their knowledge, both from academic disciplines and from their understanding of the world around them.

The application of contextual learning becomes important in improving the practical training of future specialists and its personal orientation, as it promotes integrity, system organization, and practicality. By incorporating innovative technologies into the production practices, it is possible to achieve modernization. This can be achieved by combining effective and traditional forms and methods of training. Additionally, this modernization facilitates the personal transition into professional activities, thus resulting in a shift in the goals, needs, motives, and competent actions. To address the issue of the gap between theory and practice in traditional forms of training future qualified specialists and to improve the quality of personnel training, a dual approach to professional education can be implemented. This approach involves the collaborative efforts of the educational and industrial sectors in the training of specialized professionals. It is important to note that this is not a straightforward problem to solve, as it requires careful coordination and consideration of the demands of employers.

At the factory, practical training takes place for students who are studying in an educational institution with a teacher to master the theoretical material. This training technology, known as the dual form of obtaining professional education, greatly differs from "practical training" because it focuses on actual training in production conditions rather than just consolidating theories in practice. Graduates who have studied under the dual form are equipped with the skills and knowledge to work with technology, understand all technological processes, and have experiences interacting with experienced specialists of enterprises [30]. The necessity of 70-80% of classes taking place at the factory has been scientifically proven in the context of dual education. In this model, the future specialist spends 3-4 days a week studying at the enterprise, while devoting 1-2 days to an educational institution. The technology of dual education brings everyone closer to understanding what qualifications and knowledge a specific employer needs from an employee; educational training programs are improved to meet these needs of the student and, as a result, the specialist's path to the future profession and the terms of actual training are shortened.

The academic year 2003/2004 marked the establishment of the course of Geodesy at the Faculty of Civil Engineering in Kosovo, which, at that time, was only initially for the Bachelor's level [31]. In 2012, the electronic system for student management called SEMS began to be applied within the framework of the University of Prishtina (Figure 1). Since 2015, all the students who were registered with an index during the years had their data transferred to the electronic system. Today, this system is in full operation, and more and more are being developed, thus offering the academic staff, students, and administrative staff easier work and access.

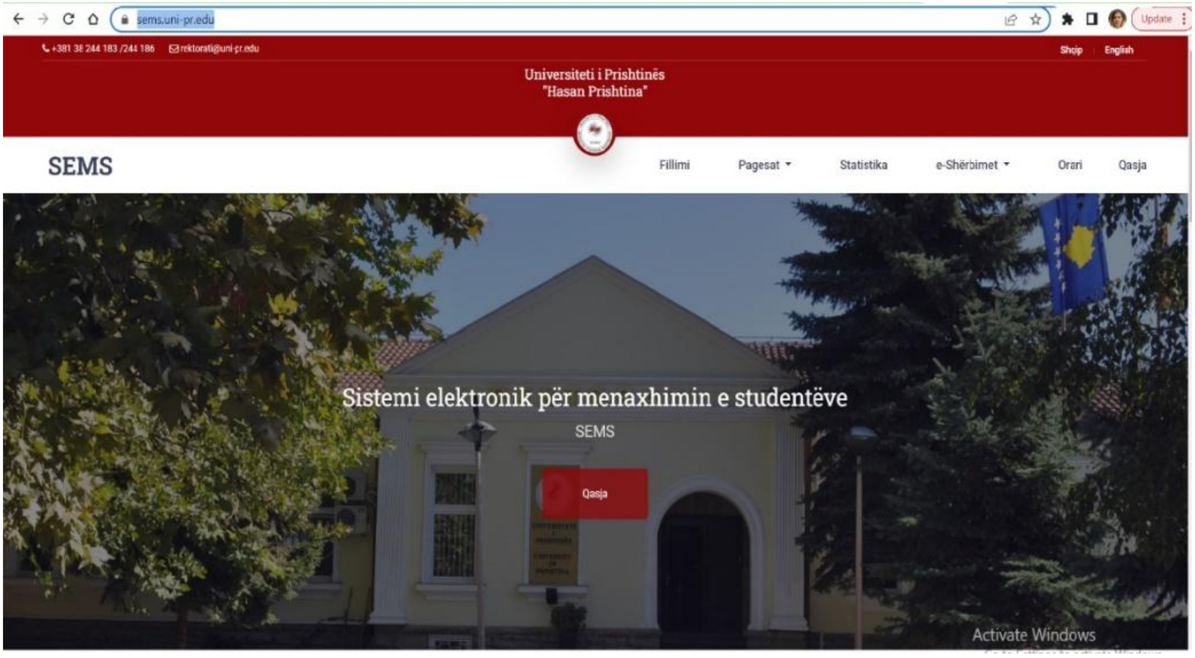


Figure 1. Electronic system for student management – SEMS.

The establishment of the Department of Geodesy within the Faculty of Civil Engineering and Architecture was decided by the council in December 2017. This decision involved the re-organization of the faculty and the delegation of responsibilities, obligations, and duties in a manner similar to other departments (Figure 2), including Civil Engineering, Architecture, Hydro-techniques, and Environmental Engineering [32].

In the academic year 2019/2020, the Department of Architecture was separated from the academic unit of the faculty, and was thus created as a separate unit. Additionally, in 2021, an advisory body (Industrial Board) was created within the framework of the Faculty of Civil Engineering. The members of the Advisory Body are representatives from the Ministers of Environment, Spatial Planning and Infrastructure, the Ministry of Internal Affairs – Department of Engineering Standards and Policies Management of Government Buildings Ministry of Internal Affairs – Emergency Management Agency, as well as representatives from the business community and business associations [33].

The role of the Industrial Board is to support the faculty in terms of improving study programs with the demands and needs of the market and providing opportunities for the students of this Faculty to perform practical work and activities in business institutions and companies. In 2021, the Department of Geodesy changed its name to the Department of Geodesy, Geoinformation, Earth and Space Observation. In 2022, the council of professors of the faculty proposed that the faculty change its name from the Faculty of Construction to the Faculty of Civil Engineering, which was approved by the senate of the University of Prishtina.

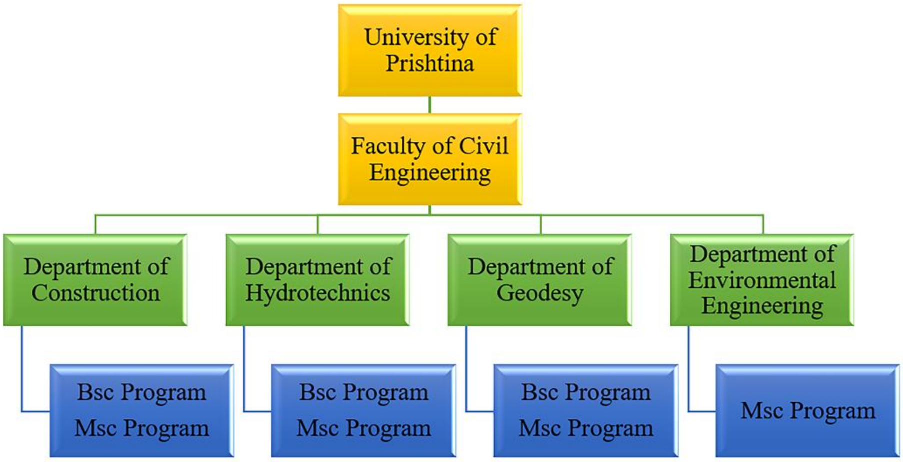


Figure 2. Organogram of Faculty of Civil Engineering.

Today, the Faculty of Civil Engineering consists of one section. The civil engineering section consists of construction, hydro-technique, surveying, and environmental engineering courses. In June 2004, the curricula for master studies were adopted for the Constructive and Hydraulic Directions in the Section of Civil Engineering, alongside the bachelor courses; in the academic year 2015/2016, the curricula started with the study program in geodesy for the master's level [34]. Environmental engineering is in the accreditation phase of the master's program in the English language, which will be the first unit in the faculty that will start with a master's level program in the English language for the academic year 2023/2024. In the framework of the departments, the laboratories are also functional, which serve for research, study, and practical work, and are well equipped with all the latest equipment that exists in the labor market (Figure 3).

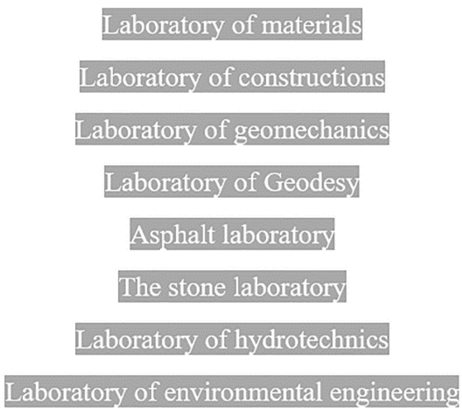


Figure 3. Functional laboratory of Faculty of Civil Engineering.

Within the framework of the faculty, several international projects won by the European Union are in process: Erasmus+GEOBIZ; Erasmus+Trento University; Erasmus+BKSTONE; and Erasmus+BOKU. Through these projects, the most up-to-date equipment from the market was acquired for the needs of the laboratories; additionally, the academic staff benefited from training. The exchange of students with partner universities took place within the framework of the projects. Additionally, the Faculty of Civil Engineering is in the process of creating an Institute of the Faculty [35].

The faculty's field of activity is the development of academic activities, teaching, scientific, and other research, which is supported by accredited study programs in the fields of Construction engineering for Bachelor's and Master's scientific and professional levels according to the Bologna process. In the faculty, professors from the countries of the European Union from all technical fields come every month; each of them holds open lectures for students, at both the bachelor's level and at the master's level.

Until now, the number of students enrolled in bachelor studies has been around 1000 during the past 20 years, and around 500 students have graduated (Figure 4). The number of students enrolled in master studies has been around 200 students and around 50 students have graduated.

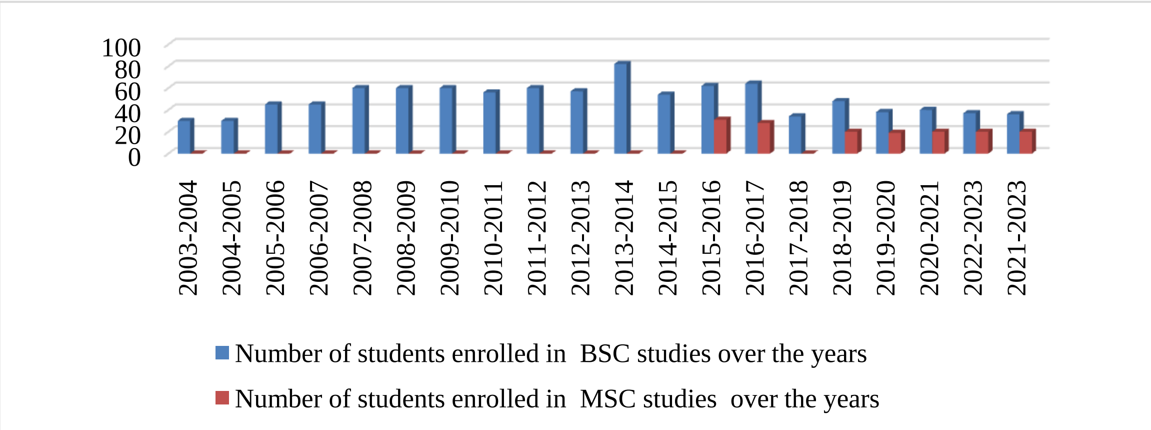


Figure 4. Number of students enrolled in BSc and MSc studies over the years in geodesy.

As mentioned in the introduction, the Department of Geodesy was opened in the academic year 2003/2004 for the first time in Kosovo, within the Faculty of Construction and Architecture as a special unit of this faculty. The number of students enrolled in this department was 30. The duration of bachelor studies was three years, divided into six semesters. Each academic year, the students earned 60 ECTS credits. Upon completion of their studies, the students were required to submit a Diploma thesis. After successfully finishing the bachelor program, the students were awarded 180 credits and were granted the title of "Bachelor of Geodesy".

In the academic year 2021/2022, the new curriculum was applied, which has been used for a four-year period and marked the sixth time that the curriculum was changed within the 20 years since the establishment of the Department of Geodesy. The aim of the Department of Geodesy was to create a master's program for students who completed their basic Bachelor's studies and were forced to continue their studies abroad. However, this was impossible to do with the existing staff and assets at that time. One possibility was that this could be accomplished through international projects. Therefore, the Department of Geodesy won the Tempus international project and was able to not only create the master's program in Geodesy, but also to create the laboratory with the latest technical equipment.

The academic year 2015/16 marked the initiation of the Geodesy Master study program, thanks to the Tempus project MPG (i.e., the development of a new master program in geodesy). With 31 students enrolled in the first year, the program at the Department of Geodesy spanned two years or four semesters. Each academic year, the students earned 60 ECTS credits. The culmination of the Master study was the completion of a diploma thesis. Upon successful completion of the Master study, the individuals were awarded 120 credits and the title "Master of Science in Geodesy".

In the academic year 2017/2018, due to the absence of internal staff, the master study program for geodesy was not accredited by the Kosovo Accreditation Agency. As a consequence, there was no competition to admit new students during that year. In the academic year 2022/2023, the new curriculum was applied, which has been used for a four-year period, which also marked the third time that the curriculum has been changed within the six years since the establishment of the Master program for Geodesy.

4.3. Projects within the framework on the Department of Geodesy

So far, the Department of Geodesy has won several projects, and these projects have benefited the staff, students, and the entire geodesy community in Kosovo: the Tempus project, BESTSDI, GEOBIZ, and Remote sensing. Through this project, the Department of Geodesy established the new master program in Geodesy. Four international universities were involved in the development of this project: the University of West Hungary (Hungary); Aristotle University of Thessaloniki (Greece) with five local partners: the Ministry of Agriculture, Forestry, and Rural Development; Vilnius Gediminas Technical University (Lithuania); and Kungliga Tekniska Högskolan-KTH (Sweden). Additionally, the following local institutions of Kosovo were involved: the Ministry of Education, Science and Technology, Kosovo Cadastral Agency, "Geo & Land" with a duration of three years 2013-2016 (MPG) and Istog Municipality.

The main focus of the project was to promote the modernization and reform of higher education in the partner countries, thus aiming to achieve various objectives. One of the goals was to improve the quality and relevance of higher education in these countries, while also fostering the reciprocal development of human resources. Additionally, the project aimed to enhance networking among higher education institutions and research institutions across both the partner sountries and EU Member States. As a final objective, the project intended to modernize the curricula in academic disciplines that were identified as priorities by the partner countries. This would involve the implementation of the European Credit Transfer System (ECTS), the three-cycle system, and the recognition of degrees [36]. At the end of this project, in addition to the master's degree in Geodesy, the Department of Geodesy also benefited from a laboratory with geodetic equipment, computer equipment, trainings in partner universities for academic staff, and the development of new teaching materials. The department has been equipped with the latest technological equipment as a result of the TEMPUS project, thus enhancing its technical capabilities.

The Geodesy Laboratory (Figure 5) has a range of geodetic equipment in its inventory, including the following: supporting equipment for a Total Robotic Station; monitoring equipment for an Advanced Total Station; supporting equipment for a Total Manual Station; supporting equipment for four GPS receivers (Base & Rover & Controller); and supporting equipment for two Digital Levels. For geodetic exercises, various accessories are available, along with eight manual levels and all the necessary supporting equipment (server, workstations, laptop, printer, plotter, scanner, projector).

Moreover, the Geodesy Laboratory has needed the following commercial software: ArcGIS, ERDAS IMAGINE, and Trimble Bussines Center. Moreover, it has needed the following free and open source software: QGIS, GrassGIS, Geogebra, FreeCAD, uDig, Geo server, Map server, Geonode, OpenLayers, Heron GIS, MapStore, GeoTools, GDAL/OGR, PostgreSQL/PostGIS, Orfeo ToolBox, Monteverdi, OSSIM, GSAL, RTKLIB, and JAG3D.

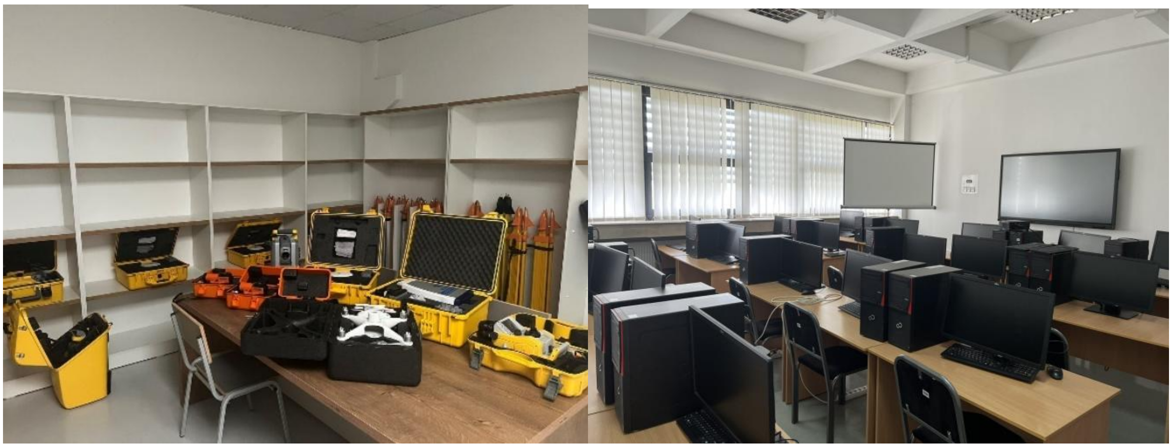


Figure 5. Laboratory of geodesy with geodetic equipment and laboratory of computer equipment.

The Faculty of Civil Engineering gained various advantages from this project, including the acquisition of geodetic instruments, which aim to enhance the teaching methods, increase the capabilities of laboratories, and improve the practical experiences of students enrolled in the Geodesy Department's bachelor's and master's Geodesy study programs. As part of this project, state-of-the-art equipment such as an integrated module RTK drone, a 3D laser scanner, and six pen tablets specifically designed for online teaching purposes were obtained (Figure 6). Additionally, within the framework of this project, changes have been made to the curriculum, thus allowing exchange students to work with partner universities within the framework of the project.

Figure 6. Dron and laser scan benefited from the GEOBIZ project.

4.4. Projects within the framework on the Department of Geodesy

The project was undertaken within the Department of Geodesy within the University of Prishtina. During the work procedure, a satellite image acquired by Pléiades Neo was used (Figure 7). Work with the urban part of the city required a need for the highest possible resolution. The following bands were used for the image: Red (620-690 nm), Green (530-590 nm), Blue (450-520 nm), and Panchromatic (450-800 nm).

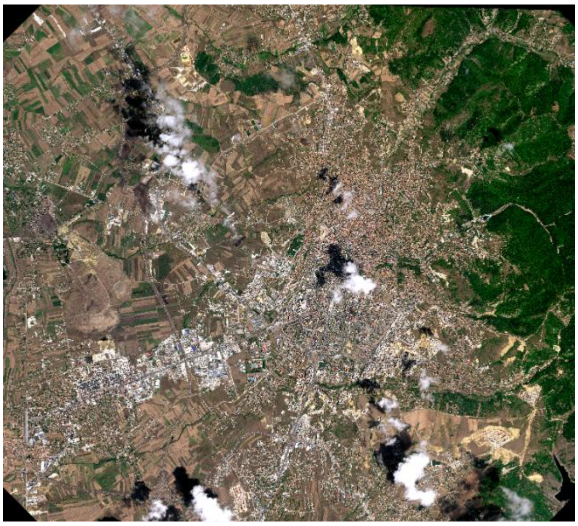
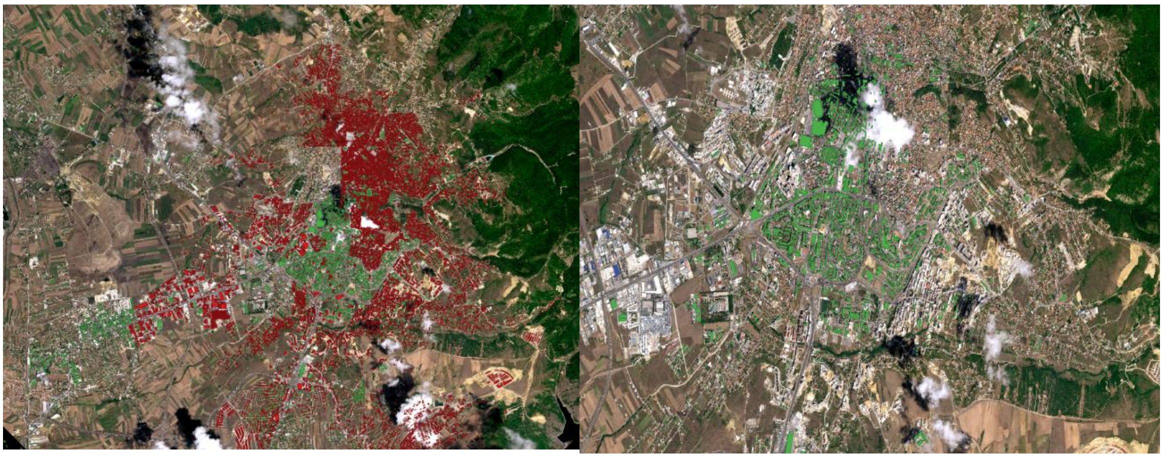


Figure 7. Image of Prishtina from satellite image Pleaides Neo.

In the framework of this project, work was performed on the identification of vacant buildings in the municipality of Prishtina. Third year BSc studies students and first and second MSc studies students were also included in this project. The image that was used was an image with a high accuracy; through this image, the identification and evaluation of illegal objects in the urban area of Prishtina occurred, where 28,450 illegal objects were digitized. A representation of the image with data on the identification of legal objects is shown in Figure 8(a); moreover, in Figure 8(b), the image after the digitization of illegal objects is given.



a) b)

Figure 8. a) Image of Prishtina with legal objects; b) Image of Prishtina after digitization of illegal objects.

Despite the transient nature of this prestigious Department, efforts are still underway to attract and retain an optimal number of talented students. Through constant monitoring and assessments, the Department is committed to enhancing the educational experience it provides and ensuring future professionals in geodesy are equipped to meet the demands of the industry. The Department recognizes the importance of a balanced approach that encompasses both theoretical knowledge and practical skills. By combining rigorous academic courses with hands-on training, students are able to develop a comprehensive understanding of geodesy. This multifaceted approach grants them the necessary tools to succeed in their future careers, be it in land management or construction.

To ensure the students are well prepared for the industry, the Department has established strong connections with various stakeholders. By collaborating with professionals, industry leaders, and academic institutions, the department is able to stay up-to-date with the latest advancements in geodetic technologies. This partnership allows for the continuous refinement of the curriculum, thus guaranteeing that students are provided with the most comprehensive and relevant education possible. Furthermore, the Department places a great emphasis on the practical application of theoretical concepts. Through the utilization of geodetic instruments and the latest software, the students are given the opportunity to not only understand the theory, but to also put it into practice. These hands-on experiences play a crucial role in fostering meaningful learning and developing practical skills that are highly sought after in the geodetic industry.

The proposed recommendations can be further developed by outlining specific steps to implement the curriculum enhancements and strengthen collaborations with the geodetic industry. Establishing pilot programs in partnership with local surveying firms and construction companies would provide the students with valuable practical experiences in real-world projects. Integrating guest lectures by industry professionals and organizing workshops on emerging geodetic technologies can further align the curriculum with current professional standards. Additionally, creating internship opportunities with municipal land management agencies or private geospatial firms in Kosovo would facilitate hands-on trainings while addressing the local labor market needs. Setting measurable outcomes, such as the number of established partnerships or the proportion of students participating in internships, will enable an effective evaluation of these initiatives and ensure their alignment with educational and industry objectives.

5. Conclusions

The Department of Geodesy has undergone major changes since its foundation, starting with the increase in the number of professors and assistants, the benefit of international projects from which the academic staff and students benefited, and laboratory equipment that served to perform exercises by students. Over the past few years, there has been a noticeable increase in the participation of academic staff in both national and international conferences. Despite the good conditions that are offered for studies, the Department has increasingly encountered the difficulty of having a stable number of students in bachelor level studies. At the moment, the Department has a stable number of students who are admitted to the Master’s level studies; however, even after their admission to studies, a number of them have found themselves in the countries of the European Union working in various geodetic jobs. The students of the Department of Geodesy are being sought after more and more by the foreign market due to their knowledge of working with geodetic instruments, the use of the latest software, and the good cooperation they have. This is an indicator that the quality of the students who finish their studies in the Department of Geodesy in Prishtina is high and in line with the demands of the labor market.

The practical component of professional training for students in the Geodesy educational and professional program is a diverse and effective process in the context of modern academic education. It aims to develop professional mobility and equip students with essential competencies. The practical component involves completing a range of tasks, including acquiring basic skills in using professional devices, gaining experience in working on real geodetic projects, and understanding the methods and rules of using maps to solve scientific and practical problems. Future professional surveyors have been trained at the Department of Geodesy of the University of Prishtina, studied in the modern conditions of university education, and received a wide range of theoretical and practical skills that they can apply in further studies, and scientific or professional activities.

This paper advocates for the integration of geospatial technologies into STEM education in Kosovo. It underscores the need for interdisciplinary collaboration among educators to develop cross-curricular activities that promote critical thinking and encourage students to explore the practical applications of geodesy within various STEM disciplines. A key prospect for future research is the development of a clear, detailed blueprint for a dynamic and inclusive geodesy curriculum specifically tailored to the unique educational and professional needs of Kosovo.

Author contributions

Fitore Bajrami Lubishtani: Conceptualization, Methodology, Software, Writing - Original Draft, Writing - Review & Editing, Project administration; Milot Lubishtani: Visualization, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Review & Editing. All authors have read and agreed to the published version of the manuscript.

Use of Generative-AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

No potential conflict of interest was reported by the authors.

Ethics declaration

The author declared that no ethics approval is required for the study

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