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The Transformation of Geodetic Education: Challenges of the Digital Era

Vladimir Oznamets [1][a], Margarita Ryazantseva [2][b], Alla Subocheva [2][c] and Elena Yakushova [3][d]

[1] Department of Geodesy , Moscow State University of Geodesy and Cartography, 4 Gorokhovsky per., 105064 Moscow, Russia

[2] Department of Psychology and Human capital development, Financial University, 49/2 Leningradsky Prospekt , 125167 Moscow, Russia

[3] Department of Strategic and Innovative Development, Financial University, 49/2 Leningradsky Prospekt , 125167 Moscow, Russia

oznamec@list.ru, { mvryazantseva , aosubocheva , esyakushova }@ fa.ru

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Abstract : The digital age is challenging the traditional foundations of engineering education, and geodesy is no exception. This study analyzes the transformation of the educational process in this economically important field. The authors focus on analyzing the readiness of the Russian geodetic training system to meet modern challenges. By examining domestic and international experience, the authors not only identify key trends but also conduct their own sociological research. An online survey of MIIGAiK students allowed to determine participant's level of satisfaction with the learning process and assess gaps in practical training. A parallel survey was conducted with the faculty of three universities offering training in geodetic specialties to analyze the pedagogical technologies used and their alignment with digital realities. The study results reveal contradictions: although the need for change is recognized by all stakeholders, a gap exists between student expectations and the current capabilities of the educational system. Based on the data obtained, the article proposes a set of recommendations aimed at updating training technologies and creating an effective system of digital geodetic education capable of training not just surveyors, but geospatial data managers.

1 INTRODUCTION

Digital transformation and new pedagogical approaches are fundamentally changing the training of surveying engineers. To ensure students' competitiveness in the labor market, universities are integrating interdisciplinarity, practice-oriented approaches, and modern digital disciplines, including satellite navigation technologies, into their curricula (Klaassen, Hellendoorn, & Bossen, 2024; Nelson, Marone, Garcia, Yuen, Bonner, & Browning, 2021). This enables graduates to effectively implement digitalization principles in their respective organizations (Jacobsson & Linderoth, 2021).

The key objectives of educational programs for training surveying engineers are: integration with STEM education (from the English Science, Technology, Engineering, Mathematics Education is an approach to learning that integrates natural sciences and engineering disciplines into a single system), develops digital competencies, and prepares students for working with big data. It is also necessary to consider the characteristics of the new generation of students, who are characterized by pragmatism, clip-based thinking, and a need for self-expression (Nepeina, Istomina, & Bykova, 2020), as well as the growing labor market demand for "soft skills" (soft skills): teamwork, critical thinking, adaptability and leadership (Božić, 2018).

[a] https://orcid.org/0000-0002-7202-3231
[b] https://orcid.org/0000-0003-0002-7193
[c] https://orcid.org/0000-0002-9075-1873
[d] https://orcid.org/0000-0002-4967-2081

Currently, we can speak of an evolution in pedagogical methods in geodetic education. The crisis of the traditional lecture system, which is incapable of fully developing soft skills, is necessitating a shift to interactive methods. Working with modern geodetic equipment becomes the foundation of training, intensifying the assimilation of material and stimulating academic activity. The role of the teacher is being transformed toward moderation and the development of problem-based assignments, with independent work by student groups taking center stage. This models future professional activity, promoting the development of not only technical but also creative and communicative competencies (A. Yu. Gura, Turk, & D. A. Gura, 2023).

Based on a scientific review and a survey of students and teachers, the most promising educational technologies were identified for use in the training of surveyors.

1. Virtual and augmented reality (VR/AR) are used for virtual fieldwork and spatial data visualization, reducing university costs and providing students with access to unique objects (Rozhi, Udovenko, & Dorozhko, 2024; Morkovin, Penkov, & Storodubtseva, 2024).
2. Online learning and MOOCs provide flexible learning of disciplines such as programming and GIS (Ervin, 2016). Electronic simulators simulating the use of surveying instruments (e.g., theodolites and levels) and topographic maps are an effective substitute for internships in a distance learning environment (Solnyshkova, 2021).
3. Artificial intelligence (AI) and machine learning are promising for automating the processing of laser scanning and aerial photography data, recognizing objects, and adapting the operating modes of complex surveying equipment (Gunderson, Holmes, & Loisel, 2020; D. A. Gura, 2025).
4. Gamification and simulations promote motivation and independence by activating various channels of information acquisition and turning students into active participants in the educational process (Dudnik & Tupoleva, 2021).

Thus, the modernization of geodetic education is aimed at creating a flexible, technologically advanced environment that combines fundamental training with the development of practical digital competencies and soft skills necessary for specialists in the digital economy.

2 MATERIALS AND METHODS

This scientific work is based on the use of classical research methods: comparison, synthesis, content analysis, and comparative analysis of the experience of training surveyors in Russian and foreign universities.

In order to determine the directions for improving technologies for training surveyors, a sociological survey was conducted among students studying in the Applied Geodesy specialty program at the Moscow State University of Geodesy and Cartography (MIIGAiK) and among teachers of three universities: MIIGAiK, the State University of Land Management (GUZ), and the Siberian State University of Geosystems and Technologies (SSUGiT).

Before conducting the survey, the following hypotheses were formulated:

1. The level of training for students majoring in Applied Geodesy is high and meets market demand. During their studies, surveying students acquire sufficient theoretical knowledge of modern technologies and the practical skills necessary for their future work. To test this hypothesis, the following were analyzed: student satisfaction with the learning process, learning conditions, assessment of instructor competence, and self-assessment of theoretical and technological preparation.
2. MIIGAiK graduates are in demand in the labor market and can earn competitive salaries.
3. Modern digital technologies are not used effectively enough in the teaching process.

To test these hypotheses, respondents' responses regarding the technologies used in the educational process were analyzed. When designing the survey, the authors drew on modern educational technologies used in Russia and abroad, as well as expert opinions regarding the technologies required by modern surveyors.

The surveys were conducted among students and teachers online using Google Forms. The results were processed using SPSS (Statistical Package for the Social Science). Hypotheses regarding the presence of statistically significant differences in the responses of respondents from different courses were tested using ANOVA, the nonparametric Kruskal-Wallis and Mann-Whitney tests.

3 RESULTS ANS DISCUSSIONS

To collect information, a corresponding tool was developed, including two questionnaires:

1. Student survey questionnaire. The purpose of the survey was to assess students' overall satisfaction with the quality of their education and their level of practical training, and, consequently, their self-assessment of their competitiveness in the labor market.

2. A survey questionnaire for teachers. The purpose of the survey was to collect information about the educational technologies used and the need to change educational technologies in the digital age.

A total of 260 students, or 87% of all students studying Applied Geodesy (specialist program) in years 1–5 in 2025, participated in the survey conducted among MIIGAiK students (71.2% were male and 28.8% were female). The majority of respondents were first- and third-year students. The student survey was conducted in March 2025.

The study revealed a high overall satisfaction with the educational process among students (average score 4.0 out of 5). First-year students had the most positive attitudes (4.16 points), while third-year students demonstrated the lowest level of satisfaction (3.74 points). This may be due to the ongoing changes in the educational program. The Kruskal-Wallis test revealed significant differences between courses ($H = 10.244$, $p = 0.023$, $df = 4$).

More than 90 percent of respondents, despite differences in course of study, highly rate the level of their practical training and the demand for surveyors in the labor market.

The results of the study indicate a significant impact of students' work experience on the following aspects:

1. Professional confidence: students with work experience are less likely to rule out employment in their field of study and are less likely to find it difficult to answer this question.

2. Self-assessment of competencies: this group of respondents tends to overestimate their practical skills in relation to the requirements of the labor market.

3. The range of opinions among respondents with no experience is greater than among those with relevant work experience. Despite the equality of median values, negative asymmetry and kurtosis are observed in respondents' responses. Respondents with work experience often provide higher satisfaction ratings with the learning process, while those without work experience often give lower ratings (Figure 1).

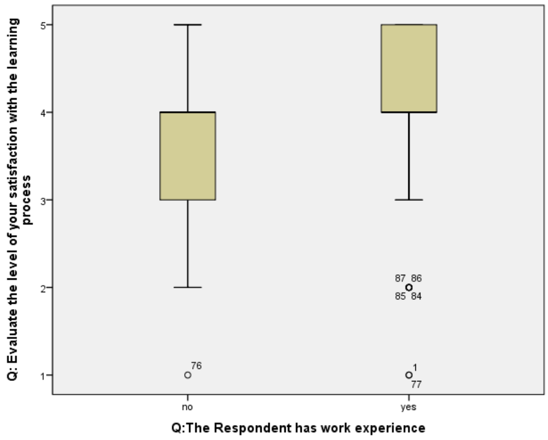

Figure 1: Dependence of the level of satisfaction with the learning process on the presence of work experience.

Thus, MIIGAIK students rate their satisfaction with the learning process and their level of practical skills quite highly. However, the survey revealed a relatively low level of use of modern teaching technologies. The data presented in Table 1 indicate the prevalence of traditional teaching methods in the educational process, such as practical classes (reported by 96.5% of respondents), laboratory work (94.5%), and practical training (78.5%).

Table 1: Results of the survey regarding the use of various types of learning technologies in the educational process.

Technology training	Course, in % of the total number of respondents studying in the relevant course					Share of the total number of respondents, %	Results survey teachers
	1	2	3	4	5		
Virtual technologies, gamification, immersive technologies, working with equipment simulators	1.5	0.0	3.1	4.3	0.0	0.02	29.2
Interactive methods	25.4	26.5	21.5	19.6	12.1	21.9	50
Practical classes	91.0	95.9	98.5	100.0	100.0	96.5	83.5
Laboratory work	92.5	93.9	96.9	95.7	93.9	94.6	91.7
Educational practices	43.3	87.8	90.8	89.1	97.0	78.5	83.3
Online education	7.5	20.4	41.5	43.5	66.7	32.3	58.3
Modeling situations	16.4	18.4	18.5	21.7	9.1	17.3	50.0

Source: compiled by the authors based on survey results.

Respondents indicated a low frequency of use of technologies such as: modeling practical production situations and interactive methods (round tables, brainstorming, business and role-playing games, conducting master classes with practitioners, creative tasks, work in small groups).

The survey results showed that virtual, immersive and gamification technologies are practically absent from the educational process.

The data obtained from the student survey conflicted somewhat with our expectations as university professors, necessitating a more in-depth analysis and theoretical consideration. As a result, we reached the following conclusions:

1. It's likely that not all students participated in the survey conscientiously. For example, some fourth- and fifth-year students did not indicate in their responses learning technologies such as laboratory work and practical training, even though these activities are stipulated in the curriculum and are mandatory.

2. Many students are unable to associate the name of a teaching method with a specific example of its implementation. In our opinion, this applies to interactive methods, which are clearly used in the training of surveyors, including in lectures, when instructors initiate discussions, engage students in brainstorming, and so on. Practical instructors are invited to many classes, and during practical training, instructors essentially conduct master classes on the use of surveying instruments and surveying technologies.

After thoroughly processing and interpreting the student survey results, we decided to survey faculty regarding their use of various technologies in the teaching process and compare them with the student survey results. Thirty-eight faculty members participated in the survey.

Respondent teachers rated the overall level of digitalization in geodetic education as average (3.4 points out of 5). The main challenges impeding the digitalization of education were identified as insufficient funding (68.4%), the slow pace of digitalization (42.1%), teacher conservatism and a shortage of qualified personnel (23.7%), and a lack of teacher motivation (18.4%).

A survey of instructors revealed that traditional teaching methods are predominantly used in surveyor training (Table 1): laboratory work, practical classes, and hands-on training. Over 58% of instructors use online learning. Interactive teaching methods and simulated practical situations are used by 50% of instructors who participated in the survey.

Analysis of differences in the opinions of students and teachers using the Mann-Whitney criterion showed that highly significant differences were noted in the respondents' answers regarding the use of virtual technologies and gamification technologies ($U = 2137.500$; $Z = -6.493$; $p = 0.000$). Statistically significant differences were noted in the respondents' answers regarding the use of methods for simulating practical situations ($U = 2207.500$; $Z = -3.035$; $p = 0.002$), interactive teaching methods ($U = 2345.500$; $Z = -2.327$; $p = 0.020$) and online learning ($U = 2266.000$; $Z = -2.341$; $p = 0.019$). Which confirmed our hypothesis regarding students' lack of understanding of the essence and names of the teaching methods and technologies used by teachers.

Insignificant differences were found in the respondents' answers regarding the use of laboratory work in the educational process ($U = 2761.000$; $Z = -1.479$; $p = 0.139$) and educational practices ($U = 2866.000$; $Z = -0.466$; $p = 0.642$).

An unexpected result is the statistically significant differences in the responses of students and teachers regarding the use of practical classes in the educational process ($U = 2573.500$; $Z = -3.053$; $p = 0.002$).

4 CONCLUSIONS

Based on a study of domestic and international experience in training engineering personnel, the results of a survey, and their own teaching experience, the authors offer recommendations for improving training technologies for surveying students and increasing the level of digitalization in surveying education.

As Russia transitions to a digital economy, the need to increase funding for higher education institutions under the "digital transformation" category is becoming paramount. Unfortunately, as a faculty survey revealed, universities currently lack modern equipment for educational purposes. We believe this problem can be at least partially addressed by establishing joint departments at universities with employer organizations. Furthermore, the creation of joint departments will expand opportunities for faculty and students to participate in real-world construction projects.

Increased funding for universities training surveyors would allow for the wider use of digital technologies in the educational process, such as VR simulators, which can fully immerse students in a virtual environment to practice complex measurements, perform office data processing, and interact with modern software (e.g., CREDO, AutoCAD). Currently, VR technologies are used very little.

Although survey respondents believe that educational programs for geodetic engineers generally meet employer needs, it seems appropriate to add field and office work to the curriculum for geodetic engineering students, using modern methods of obtaining geospatial data, particularly laser scanning technologies (mobile, terrestrial, and aerial), utility locating (using route finders, ground-penetrating radar, UAVs, etc.), and modern GNSS satellite positioning methods. However, universities currently lack the necessary equipment to integrate such plans into the curriculum.

Therefore, modern education in geodesy should be based on digital technologies, interactive methods, and interdisciplinary connections. This will help train specialists capable of working with innovative instruments and solving complex spatial problems. A modern surveyor is not simply a specialist with a leveling rod and theodolite, but a geospatial data manager. Therefore, their university training should focus on developing competencies in collecting, processing, analyzing, managing, and interpreting spatial data using the full range of digital technologies.

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