Improving the educational process to address issues of digital technologies development in the road industry

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Abstract. The features of the educational process in training personnel for the road industry at Altai State Technical University are considered, taking into account the development of the digital economy. Much attention has been paid to key technologies that provide digitalization for the road industry. The set of disciplines necessary for obtaining knowledge in digital technologies for the further activities of university graduates is analyzed. When studying bachelor’s and master's programmes, future specialists acquire knowledge of modern methods in computer-aided design of highways, geographic information systems in construction, information modeling and intelligent transportation systems. During the educational process, an understanding of the importance of implementing an automated control of equipment in road construction works using onboard information management system is also formed. The directions of scientific research are described in which students studying Master's Programme in Highway Design Construction and Management work. These studies make extensive use of digital technology. The analysis of road traffic accidents for identifying hazardous sections is given, as well as the analysis of the current road state with the development of measures for improving the transport and operational road condition. Current research areas using digital technologies are in demand in modern conditions.

1. Introduction and Problem Statement
Specialist training is of great importance in the strategy of digital economy development. Currently, in training specialists for the road industry, much attention should be paid to the use of digital technologies in road construction. In this case, it is necessary to provide training in modern methods of road design and in the use of digital technologies for road safety and road operation.

Obtaining knowledge in developing digital terrain models and digital models of situations that are used in the road design is of great importance.

The three-dimensional road design is also relevant for providing visual smoothness and clarity of the road. When designing a road in three-dimensional space (3D design), a virtual (digital) road model is created, on the basis of which you can check the geometric consistency of the model.

Future specialists in the road sector must have an understanding of GIS technology, which is an essential element of the modern economy. Regarding this, the necessary technologies and software tools have been developed at present. The road industry also has an understanding of information technology importance.

In the field of higher road education, more attention must be paid to computer-aided design and geographic information systems in the educational process. These technologies have to become an integral tool of road engineer activities for university graduates.
Information modeling and intelligent transportation systems (ITS) are the key technologies for the road industry digitalization. Intelligent control systems must be actively implemented on the roads. Students need to obtain an understanding of the feasibility of installing an automated management system (AMS) for the appropriate equipment. They also must acquire knowledge about the advantage of automated management systems based on 3D technology that will improve the quality of performed work and increase the efficiency of using equipment with savings in material and labor costs, providing a quick return on investment.

2. Features of the educational process, using modern methods of digital design and effective executing road construction works.

The high school must take into account the needs of the modern economy. Currently at the Altai State Technical University after I.I. Polzunov in the curriculum of the Department of Road and Airfield Construction, there are disciplines directly related to informatization of the road sector, where elements of the digital economy are used including the advantage of its application in the road industry.

Thus, the bachelor's programme includes the following disciplines: Automated Road Design, Geographic Information Systems in Road Construction, and the Master's programme in Highway Design, Construction and Management includes the disciplines:

- Theoretical Aspects of the Geographic Information Systems Development;
- Theory of Modeling Flow Movement;
- Methodological Aspects of Intelligent Transportation Systems Development;
- Special Issues of Road Design;
- Modern Methods of Road Design.

When teaching these disciplines, much attention is paid to modern methods of highway design. Students have an understanding that the design of such complex technical structures as highway requires a comprehensive analysis of a variety of factors to ensure the required transport and operational characteristics of the road and traffic safety. Therefore, the choice of optimal technologies and tools used for design plays a decisive role.

For the development of the digital economy in the road industry, it is very important to obtain relevant knowledge in this direction during training.

When studying the discipline Modern Methods of Road Design, students get acquainted with digital terrain modeling that is used to construct earth surface cuts in a given direction, to find coordinates and elevations of points for creating plans, longitudinal and transverse profiles, etc. A digital terrain model (DTM) consists of:

- digital elevation model;
- digital situation model;
- digital model of the geological and hydrogeological structure of the area;
- digital model of environmental parameter distribution, etc.

Working with CREDO software package students get acquainted with digital elevation model (DEM), digital model of the situation (DMS), digital geological model (DGM).

The digital elevation model is formed on the basis of points, structural lines, and elevation contours. In this case, a triangular network is created, with the help of which the heights of points with known coordinates can be calculated, sections in a given direction are constructed, the relief is displayed using elevation isolines, legend symbols of slopes and cliffs.

Creating a digital terrain model, students get acquainted with the recommended sequence of work. Horizontals in the form of broken lines are used to visualize the road carriageway for various layout types. There are two methods to analyze the relief: constructing a cut along any broken line drawn along the formed surface, and the second method implies viewing the relief in the three-dimensional perspective.

Students study the recommended work order when creating a digital model of the situation. The digital model of the terrain situation includes areal objects (settlements, platforms, individual
buildings), linear objects (roads, watercourses, power lines) and point objects. The information on the terrain prepared in the form of a digital model should also include land-use boundaries, status and characteristics of existing infrastructure objects, such as roads and railways, utilities, buildings and structures, as well as data on natural objects – such as wetlands, rivers and other water bodies, forest massifs and relief.

Students get acquainted with AutoCAD Civil 3D. This system is an innovative solution. Its obvious advantage is a dynamic design environment, built on the basis of the well-known and widely used AutoCAD platform. Using an automated design system AutoCAD Civil 3D allows you to perform any stage of design including construction, reconstruction and repair of roads [1].

Structurally, the design process in AutoCAD Civil's 3D should include the following steps:

• preparing a digital terrain model;
• defining the road route in the plan and profile;
• 3D modeling of the road;
• calculating the volume of the work and creating the output documentation.

Students begin to understand that the digital elevation model (DEM) is the basis on which the entire dynamic model of the road project is built. The digital elevation model is used to create longitudinal profiles of linear structures, and is the target object for determining project slopes and profiling.

At the design stage, several options are being worked out for passing the road route with an assessment of technical and economic indicators and taking into account the features of the terrain and other obstacles. Three-dimensional modeling of a road begins with the definition of typical transverse profiles (structures).

Calculating the earthwork volume is carried out along the axes of the cross-sections and surfaces of black marks (earth) and surfaces of black marks (earth).

In the process of training, attention is paid to improving geographic information technologies in the road sector using digital aerial photography of roads and mobile laser scanning. For planned high-altitude justification of GIS works, GLONASS-based satellite measurement technologies are being implemented.

GIS remains an integral part of the overall process, playing a dominant role in the operational phase of roads. The process of operating roads in the Russian Federation is based on a diagnostic procedure. When diagnosing roads, the main attention is paid to variable parameters (evenness, adhesion, strength, defects of the carriageway and to other structural elements of the road). Based on the diagnostic results, road sections that do not meet regulatory indicators are determined. A set of measures to improve transport and operational conditions is being appointed at these sections. Much attention is paid to studying capabilities of modern GIS using the ArcGIS software package as an example.

Students acquire skills in solving practical problems using geoprocessing operations in GIS, as well as creating and maintaining spatial databases in modern GIS. In practical classes, they solve the task of investigating the territory in the GIS for selecting places for road design and operational measures. The training process uses the Arcview3.2 / ArcGIS technical documentation package.

The mathematical basis of the map is studied, taking into account the basic methods of mathematical cartography implemented in modern GIS packages.

Thus, geographic information systems are a tool for engineering and road management and play a significant role in the implementation of information modeling.

In the master's programme, considerable attention is paid to studying methodological aspects of the developing intelligent transportation systems (ITS), which allow automated search and adoption of the most effective ways to control transport and road complex of a region, specific vehicle or group of vehicles.

The key technologies for digitalization of the road industry are information modeling and intelligent transportation systems (ITS).
When studying the discipline Modern Technologies for the Mechanization of the Road Construction and Operation, students get acquainted with modern road equipment. The task of the road equipment management systems is the formation of the surfaces of each road layer (subgrade and pavement). For operation of such systems, it is necessary to use 3D digital models representing the surfaces of the structural layers of the subgrade and pavement, each of which requires a certain type of road equipment at each stage of the work [2].

Currently, modern road equipment is being introduced at domestic engineering enterprises. Thus, some machines are equipped with an intelligent leveling system that allows accurate positioning of the excavator bucket or the dozer blade. It is planned to create a new bulldozer with a full fledged onboard information and control system, which will provide control over the functioning of all units, will fully automate the control of the machine and its working equipment, including remote control. This will increase the level of productivity, and the operator of the equipment will be able to control several machines remotely at the same time.

3. Research areas for using digital technologies in road construction, road safety and road operation

The research work in using geographic information technologies was carried out in the following areas:

- analyzing traffic safety and accident rate on highways;
- analyzing operational conditions of roads and developing measures to improve transport and operational conditions of roads;
- analyzing road lighting conditions and developing measures of their improvement;
- analyzing current road traffic conditions and their improvement for road users with disabilities.

In carrying out these research works, digital terrain models and digital situation models were used, as well as the necessary software systems.

One of the areas of scientific research carried out by master’s students in the course of work on their theses is the use of geoinformation technologies to identify foci of traffic accidents concentration in the city. To solve this problem, in the GIS an information model was developed which allows creating interactive accident maps. Using this map, an analysis of high road accident concentration spots was carried out to develop recommendations indicating measures reducing the number of accidents. Such studies give an approach to solving the problem of ensuring road safety and the effective organization of the road network in settlements.

To accomplish these tasks, the ArcGIS software package produced by ESRI was used for it has the most complete range of functions for creating and analyzing spatially distributed information. Using GIS the most hazardous, in the sense accident rate, road sections were identified.

The interactive accident map constructed by means of ArcGIS represents a visual model of accident foci in the urban area.

The created geodatabase of traffic accidents has its own independent value and assumes annual updating data for the actualization of the interactive accident map [3].

Research in this direction allows solving one of the most important tasks of road and transportation management.

For analyzing accident data on the regional and federal roads, the geographic information system of the web version of ArcGIS, ArcGIS Online (ESRI), was used. ESRI software can be applied for a wide range of tasks related to spatially distributed objects and analysis of spatially distributed data. It is successfully used in the areas of cadastre, land management, utility management, surveying and others. The choice of the ArcGIS Online system is due to the fact that it is, first of all, an instrumental GIS that works with many formats of geographical data, to which attribute (descriptive) data can be easily connected.

When conducting studies on traffic safety, a digital topographic base was used, corresponding to the locality, consisting of spatial data sources in shapefile format and including the necessary geographic layers.
In ARcGIS Online, an interactive thematic map was created that allows to visualize data on traffic accidents specified in geographic coordinates, view information about them and search for accidents by some of their features or by their spatial position or combining spatial and logical conditions.

In addition, the GIS allows to perform visual and quantitative analysis of the road features, that is, with the help of GIS we obtain complex information about the object, which allows to make more informed decisions on the road maintenance and management.

Using information on the number of accidents, it is possible to classify sections of roads according to the degree of danger and show this on the map with the help of symbols (the symbol class “Gradient coloring” was used).

Using the created interactive accident map, you can view information on any accident and on various road sections. In addition, as in any GIS, it is possible to search for accidents or road sections using spatial-logical queries. You can also add various Internet resources to the created map.

This map can be updated by adding new roads, new data on accidents. The map is a road accident analysis tool. Using this map in GIS, you can monitor the situation on the roads, and also use it as the basis for making management decisions to reduce road accidents.

The resulting GIS accident map provides comprehensive information about road and traffic accidents, and gives a possibility to search for objects of interest, all that makes the content of the accident analysis more complete and functional.

One of significant importance is a research work carried out by master's students by means of GIS technology which allows analyzing road accidents to identify accidentally hazardous road sections and develop recommendations for reducing accident rate. The expediency of using GIS technologies in analyzing the current state of roads and their operational conditions for the following development of measures improving their transport and operational conditions is established. When conducting these studies, digital technologies were used, which allow performing spatial analysis of various road features and situations. Working on of digital solutions for people with disabilities on the roads is also noteworthy. For them, digital applications and modern means of communication are extremely useful.

The main objectives of these studies are the implementation of a comprehensive analysis of the causes and conditions causing road traffic accidents and the subsequent assessment of the effectiveness of decisions made, including the use of mathematical modeling methods. On this basis, proposals were prepared on priority areas in the field of road safety.

A number of studies were devoted to the problem of analyzing the state of the road surface in urban conditions, as well as in the districts of the Altai Krai. These studies were performed in the ArcGIS program.

Based on the results of the visual analysis, the collected data was reflected in the updated maps of a particular area in a visual format. On these GIS maps, roads with minor and significant defects were highlighted with corresponding symbols. As a result of the studies, measures were proposed to eliminate defects on specific roads, which are currently taken into account when repairing problem sections of roads, both in urban conditions and in several regions of the Altai Krai.

Studies were also conducted to analyze the lightning of streets and roads in the city of Barnaul. The use of the ArcGIS program allowed us to present the results of our studies in a clear, systematic form. Based on the data GIS-maps were created. At the same time, sections of roads and streets with poor lighting were revealed. Recommendations have been developed on optimizing the lighting system of road sections, as well as on the effective use of LED lighting lamps. GIS-maps were obtained showing the state of illumination in the studied settlement.

The master's theses also discuss digital solutions for people with disabilities (with hearing and vision problems). For them, digital applications, modern means of communication are extremely useful. When performing such studies, a state analysis was carried out to improve the traffic conditions of road users. In the course of these studies, existing means are analyzed that ensure the safety and comfort of movement for people with limited mobility in the urban environment. At the same time, an experimental analysis of the state of existing conditions for ensuring the safety and comfort of movement of these population groups is performed by means of GIS.
As a result of these studies, an interactive GIS map is created, which can be further developed when new objects appear for road users with disabilities. Based on the studies, recommendations have been developed on creating new facilities that increase the safety and comfort of people with disabilities in a specific urban environment.

Scientific research carried out using digital technologies in the above areas is relevant in modern conditions. Its implementation is necessary for the road industry.

4. Conclusion

To train qualified road industry specialists possessing knowledge of digital technology the following problems need to be addressed:

- acquiring knowledge of modern methods in the road design;
- studying the importance of digital models in the issues connected with road building equipment management with a computer-aided 3D design system.

Of the significant importance is a research work carried out by master’s students by means of GIS technology which allows analyzing road accidents to identify the most hazardous road sections and develop recommendations for reducing their accident rate. The expediency of using GIS technologies in analyzing the current state of roads and their operational conditions for the following development of measures improving their transport and operational conditions is established. When conducting these studies, digital technologies were used, which allow performing spatial analysis of various road features and situations. Working on of digital solutions for people with disabilities on the roads is also noteworthy. For them, digital applications and modern means of communication are extremely useful.

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