

Virtual Technologies possibilities for improving background knowledge of Civil Engineering Education

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Abstract

A new era with rapid technological changes, digitization, new forms of labour organization requires innovative ideas for modern education using a virtual learning environment and available technical means. This article discusses the prerequisites for creating a concept of a universal curriculum for first-year students in construction specialities for teaching the fundamentals of technical disciplines - that means basic engineering education, with integrating the Building Information Modeling (BIM).

The Building Information Modeling (BIM) methodology includes the concept of combined information about all the parameters of a three-dimensional object. This is universally supported by modern technology and can be used to develop innovating teaching methods.

To identify the prerequisites for the concept of a universal electronic course, an analysis of the IMD statistics was carried out and a generalized overview of the content of educational programs in the main technical disciplines of higher educational institutions of the countries of one graphic region was conducted.

Keywords: *BIM; Virtual Technology; First-Year Student; Civil Engineering Education.*

1. Introduction

The main task of modern higher technical education is to provide the labour market with specialist engineers with the necessary knowledge and skills to perform work tasks of various levels of complexity (Tabas at. all, 2018).

The need to review and analyze the curricula of several higher educational institutions of the countries of one graphic region to study the main technical disciplines is probably due to the difference in the teaching of higher technical education in neighbouring countries, which affects the statistical indicators of the countries competitiveness as a whole and the success of specialists' work.

Comparison, analysis and generalisation of learning outcomes of first-year basic technical subjects will help assess the possibility to use an integration of BIM - Building Information Modelling (Hjelseth, 2018).

The three-dimensional modelling program Revit allows us to create different three-dimensional objects for visualizing and a better understanding of educational topics since it is Revit objects that contain complete parametric information about the object and its parts, as well as use information parameters a particular object throughout its entire life cycle.

2. Research methodology

2.1. Analysis of statistical information

Analysis of the statistics of the world ranking of countries' success is necessary to determine and select universities with similar ratings and geographic positions, whose curricula are supposed to be analyzed.

For the study, it is necessary to analyse statistical information of the world and regional ratings taking into account the regional grouping of countries (Table 1).

Table 1. Composition of sub-regions and regions of Europe.

Western Europe	Austria	Netherlands	France	Switzerland
	Italy	Denmark	Spain	Iceland
	Belgium	Norway	Germany	United Kingdom
	Luxembourg	Finland	Sweden	Ireland
	Cyprus	Portugal	Greece	
Eastern Europe		Bulgaria	Estonia	Hungary
		Latvia	Romania	Slovak Republic
		Czech Republic	Croatia	Lithuania
		Poland	Slovenia	Ukraine

Source: IMD WORLD TALENT RANKING 2019 (November 2019)

Then, according to the analysis of the Global Talent Rating, it is necessary to find out in which countries of the same region IMD indicators are approximately at the same level.

IMD evaluates three factors: the Investment and Development, the Appeal, and the Readiness factor (Table 2) .

Table 2. The IMD World Talent Ranking 2019.

Overall Rank 2019	Country	One Year Change	Overall Score 2019	Investment & Development	Appeal	Readiness
1	Switzerland	-	100.00	2	1	2
6	Norway	-3	85.95	3	10	21
8	Finland	-1	83.14	10	16	3
11	Germany	-1	80.78	11	9	14
27	Estonia	+1	66.88	21	23	35
28	Lithuania	+8	66.51	14	35	33
31	Slovenia	-1	64.16	22	42	30
34	Latvia	+1	62.08	12	48	40

Source: IMD WORLD TALENT RANKING 2019 (November 2019).

One of the key characteristics of leading economies is that they strive to achieve alignment between talent the demand they face and the internal supply of talent they are able to offer.

In the Table 3, there is showed the ranking of the three leading economies in the region with indicators for three factors. It can be seen that regions have different strengths in relation to the factors studied.

Table 3. Ranking of Eastern Europe countries.

Ranking	Country	Investment & Development	Appeal	Readiness
27	Estonia	21	23	35
28	Lithuania	14	35	33
34	Latvia	12	48	40

Source: IMD WORLD TALENT RANKING 2019 (November 2019).

This sub-region is led by Estonia, Lithuania follows, and Latvia closes the sub-regional top (IMD, 2019). The ranking shows the proximity of positions in the economic achievements of countries, which is the rationale for the choice of educational programs of universities for further study.

2.2. Learning outcomes of higher technical educational institutions

According to the above world ranking data, universities from the countries of one subregion - Eastern Europe - Estonia, Lithuania, Slovakia, as well as countries with a high rating of Western Europe - Norway, Finland and Germany - were selected for comparative analysis of programs of basic technical subjects of the first year of study and summarizing the results of the analysis. The results of training in the specialities of construction (Tabas, B., Beagon, U., & Kövesi, K. (2018) were summarized by teachers of the TTK UAS Estonia, Relevance of competence according to Graduate Attributes and Professional Competencies (2014), and are shown in Table 4.

Table 4. Construction specialty programs' learning outcomes.

Learning outcomes	Relevants of competence
1. the commonly used principles of building construction, design and building materials using.	1. the need to study and understand the design and construction processes, interaction and coordination of work processes between partners of the construction process both locally and internationally.
2. legislation, standards and technical norms in the construction field.	2. acquisition of the fundamental knowledge on building technologies, on managing execution of smaller structures, on production of building materials for designing of simple constructions, presenting own solutions of technical and economical issues within construction of various types of constructions.
3. the technology of main building processes.	
4. the principles of building cost estimation and is able to compile a budget with time estimation.	
5. the main requirements of occupational safety and the ability to evaluate the effect of building on the environment.	
6. ability to use field-specific computer programmes.	

The educational outputs of all programs correspond to the tasks of training competitive specialists - civil engineers design and calculate, build, plan and manage the work of the industry. Requirements of qualified preparation for solving today's construction problems, such as changes in the environment and climate, due to industry expectations regarding innovation and production, since Civil Engineering goals are the development of the main infrastructure needed for society: the assessment, planning, design, construction, operation and maintenance of infrastructural works (Hjelseth, 2015).

3. Background for the development of a modern universal curriculum design

3.1. The meaning of engineering thinking

Engineering thinking should ensure the use of acquired knowledge to solve practical problems that were or were not taken into account during his training. In other words, the engineer must be able to apply all the knowledge gained and find the optimal solution for a standard or non-standard task, which means processing the initial data about the object, creating and regulating the relationships between the parameters of the object or between objects, or between the object and the environment.

Therefore, the task of higher technical education is to choose such subjects that provide the necessary set of knowledge to ensure engineering thinking, and it is very important to start with basic technical subjects of the first year of study. The first year of study is difficult for students - entering a new learning environment with new information, requirements, terminology, the need to independently plan and carry out academic work. Therefore, the content and form of basic technical subjects should be intuitive, interactive, with mandatory feedback so that the student can work independently to achieve the desired level of knowledge.

The problem of using innovative teaching materials after changing them is to update the content, develop new exercises for students' practical and independent work, require their implementation and adaptation, and then track the success of their use. This process takes some time, and by the time it is accepted and approved for use in training, often innovative teaching materials are outdated and lose their innovative value.

The use of BIM in education is possible for the creation of small courses or modules of large course-integrated interdisciplinary projects and distance cooperation between higher education partners.

The task of integrating and adopting BIM into existing courses and curricula is more important because it is primarily a convenient visualization tool.

3.2. Mobile learning

Accessible basic education should include various teaching methods. New technologies have greatly expanded learning opportunities with mobile devices. Now users can access a huge amount of the data they need without restrictions at a convenient time for them.

The younger generation is very interested in learning through interactive mobile applications - whether it be videos, presentations, virtual reality VR, augmented reality AR or gaming learning applications. This democratization of VR/AR will increase accessibility and affordability of VR/AR, and these technologies will be something as usual as mobile technologies within next few years, making it easier to integrate VR/AR (Martin-Gutiérrez, 2017).

Online training courses consisting of short videos and game exercises, simulators, tests are very effective due to their simplicity, cost-effectiveness and form of the game (Ovtšarenko et al, 2019).

Group training is also very effective using mobile devices - between groups of people in discussion forums, blogs, social networks there is an exchange of ideas and information.

E-books also provide an excellent opportunity for mobile learning.

Mobile learning expands the scope of training by providing access to quality content not only from the classroom.

Investment in this field of mobile learning using technologies such as AR/ VR, Artificial Intelligence AI, robotics, and blockchain in education is rapidly growing and in 2025 it will be \$22 billion compared to 2018 \$4 billion (Thomas A Singlehurst et. al, 2019).

3.3. Learning modules

The concept of creating small training modules for one course has many advantages, including the sequence and coordination of training topics with each other, the repetition and consolidation of basic knowledge on various topics with the creation of logical chains of connections, additions to the knowledge gained. There is possible to use small training modules to create intersubject communications, which is an indisputable advantage. E-learning can also be used as timely support for a core e-learning course, helping users quickly view past exercises and tests, using personalized access to digital content and speeding up the learning process.

3.4. Integration BIM into existing courses

The problem of using innovative teaching materials after their development and change is to update the content, develop new exercises for students' practical and self-work, perform and adapt them, and then track the success of their use. This process requires considerable time and often innovative teaching materials - by the time it is accepted and approved for use in training, it is outdated and loses its innovative value. The integration of BIM into existing academic subjects will help, first of all, to visualize any topic of a technical subject, which will significantly reduce the time for understanding and mastering knowledge on this topic. In addition, to ensure intersubject communications of basic subjects - graphics, physics and mathematics - with use of the same spatial objects will significantly enrich and complement the content of these educational subjects, the teaching process will be very effective, with the introduction of parametric modelling. As the most advanced technological solution, engineers need BIM knowledge and technology. To reduce the loss of time spent learning BIM, the best solution is to integrate and adapt BIM into existing courses and training programs, rather than organizing individual BIM courses (Hjelseth, 2018).

4. Conclusion and recommendations

BIM, included in other subjects, is important as a means of improving learning, for student work and collaboration (Sampaio, 2018).

The expected impact - the inclusion of BIM in existing academic subjects can help increase the competencies of future specialists and their competitiveness.

Significant changes in the content of traditional subjects using visualization and parametric information of educational objects, the use of mobile devices will increase not only the interest of students but also increase the effectiveness of the educational process (Lassen et al., 2018). And the use of BIM at an early stage in the training of specialists can be achieved without major formal changes in the curriculum.

Connection with modern technologies used - students' participation in ongoing work projects using BIM provides an opportunity for more in-depth training, cooperation.

Three-dimensional modelling programs allow us to create various three-dimensional objects for visualization and a better understanding of educational topics since objects contain parametric information about the object and its parts, which allows you to create intersubject communications and use them effectively for better assimilation of logically related educational material.

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