Multidimensional Modelling in the Educational Process Based on the Block Cluster Model

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Abstract. In the study of certain technological processes, students lack practice to a large extent therefore it is difficult to understand assimilation of a significant part of the educational material. As part of academic studies there is no opportunity to demonstrate the full technological cycle of construction and installation works. Multidimensional modelling tools, 4D models in particular, redound to demonstrate technological processes with high detail remotely from the construction site, 4D model tools allow to demonstrate how technological solutions can affect the duration of work and the quality of the realized objects. Similarly construction industry where the effect of the introduction of information technology is achieved as the reduction of term and cost of the project taking modern methods and tools in educational processes allow to improve the competence of students. The creation of detailed models with a developed work breakdown structure requires a significant amount of resources, including the time of work of highly qualified design engineers. This article discusses issues of labour costs reducing for the creation of multidimensional models due to applying the cluster system of model formation.

1. Introduction
The development of the construction industry in the field of information modelling, the introduction of BIM technologies, the processes of design, construction and operation prove the effectiveness of this technology [1,2]. To realize the potential of optimization of technological and business processes through the use of modern technologies requires specialists with high competence in this field. In this regard, it is impossible to imagine the training of specialist such as civil engineers without the use of tools in educational processes similar to those used by advanced developers and companies specializing in BIM technologies [3,4].

The article is written based on 3 years’ experience of implementation of the multidimensional modelling technologies in the educational process on the basis of study course «Computer-aided design methods in organization and project management». The main purpose of the educational course is getting students competencies in the field of information modelling, and also the demonstration of the functional features of information models to make organizational and technological solutions at the stage of technological design [5].
2. Methods

When developing projects based on a multidimensional model it is necessary to take into account the level of basic qualification of the developer, this aspect due to the lack of generally current methods of multidimensional design and innovation of the technological approach especially in domestic practice. One of the solutions to this problem can be the creation of a block-cluster structure of a multidimensional model that is the creation of a library of standard and dynamic unit blocks [6].

On the basis of unit blocks, which out of technological features are combined into organizational and technological clusters.

Organizational and technological cluster is an association of several homogeneous single blocks, which can be considered as an independent unit with certain properties necessary for solving organizational and technological tasks [7].

The use of cluster structure will allow for a short period of time to use the technology of multidimensional modelling in groups. In the aggregate organizational-technological clusters constitute a single multi-dimensional model of the object.

The assessment of the assimilation of the study material was carried out according to three indicators: involvement in the learning process, acquisition the skills of working in specialized programs of the complexes, as well as an understanding of the technology of construction and installation works.

Involvement was taken into account on the basis of systematic verification of the developed model at each stage. The assessment of the degree of mastering skills in specialized programs and complexes was made in relating to the complexity and detail of the information model developed by students. The general understanding of the technology of construction and installation works largely depends on the students' progress in related disciplines which makes it difficult to apply the results of this assessment to the general results and a correction factor for the correlation of this aspect was introduced to reduce the error in forming the overall assessment of the adopting of the material [8,9]

3. Results and discussions. Typical structure of the single block of a multidimensional model

Creation of single elements requires consideration of the block structure of the project model, this requirement is due to the need to ensure the flexibility of the model, this approach also meets the requirements of the model's adaptability and the ability to integrate with other models and their components.

Primarily, the model is based on the structure module (figure. 1) which is a visual three-dimensional model created in 3D CAD applications. From the point of view, the design process of optimization, it is supposed to use a single model for all design participants, generating its details in the process of project implementation. To eliminate constructive, 3-dimensional and technological collisions, the graphic model must reflect all the structural elements of the project, as well as equipment, engineering systems, temporary buildings and structures, erection openings and much more, depending on the project’s objectives. However, for a curriculum the creation of a simplified three-dimensional model can be easy and more effective solution, for example, a simplified model for solving individual problems of an organizational-technological conditions.

At a certain stage the assessment of the technological decision, it is required to determine the estimated cost of the designed work. Often, it is the cost indicators that are key to the approval of the technological solution in the project. The assessment of the estimated cost of a single unit of the model is effectively due to the formation of the cost of work at an early stage of design with high accuracy. Non-standard projects both from a constructive and technological point of view require a more accurate assessment of the amount of upcoming investments. The sooner such an assessment is made, the more likely the customer and investor will make a better decision. The resource-cost block allows to give such an assessment [10]. The division of the model into single elements allows to choose not an analog object but its integral part. The using single blocks as components of analog objects, we are able to estimate the cost of individual parts of the project. In general, this allows to increase the accuracy of preliminary
estimates, despite the use of aggregate indicators at the early stages of the project. Combining the dynamic links of the constructive and resource-cost blocks allows us to assess the dynamics of the required investment of the project in the design process and make changes to the architectural and structural parts of the project.

Figure 1. Block diagram of a single unit multidimensional model

The use of visualization in the process of developing scheduling projects provides optimal communication links for the participants of the process, as well as a deep understanding of technological processes and the sequence of their implementation.

Combining the structure and technological block into a single model allows the designer to identify inconsistencies in the logic of the scheduling, the part of the scheduling calendar project does not match
the constructive, this revising takes place almost automatically and reveals up to 90% of conflicts and inaccuracies. For example, the planner set the parallel production of finishing, electrical installation and installation of engineering systems. In this case, the multidimensional model will identify the occurrence of congestion in some areas of the site, which as a result leads to a decrease in labor productivity rates for working teams. Then the tasks need to be redistributed, so that the work could be implemented on separate work zones. The increase in the duration of the project is happening. However, the subsequent execution of work, with the division into work zones will eventually allow to complete the task with maximum productivity. 

*The analytical block* is responsible for collecting and classifying information related to the individual characteristics of the model elements (structural loads, performance requirements for materials and equipment, etc.). With account for the technological complexity of the constructed objects, there are problems that can be solved only with the use of computer modeling methods (placement of large equipment, comparison of technological options for construction and installation works, etc.). Multidimensional modeling technology is the best way to simulate the construction process before its actual start with a minimum amount of labor and other resources. This technology provides an opportunity to go through the construction process and provides a basis for identifying potential problems.

4. Conclusions

The rationale for using the information model as a planning method for specific projects it is obvious that the model transfers information more clearly, information is available to the majority of participants involved in the process of developing and using the model. The information model allows optimally to visualize the sequence and content of the processes of interaction between project participants even at the early stages of project implementation. This approach is possible regardless of the features of discipline or on an interdisciplinary scale.

According to the results of the students' work the development of technological solutions based on the information model, and as a result good indicators of involvement in the learning process, application of the material as the understanding the technology of construction and installation works and processes were identified.

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