Nurturing cognitive skills in undergraduates with the help of ontological analysis

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Abstract. The article deals with the didactic problem that arises in the two-stage system of bachelor's study - master. During the period of study in the master's program, the bachelor needs to make a qualitative leap in the style of thinking and move from the visual-language thinking of the bachelor to the critical conceptual thinking of the master. Why bachelor needs to acquire cognitive skills as soon as possible. The article substantiates the use of the ontological analysis method as a didactic tool for teaching undergraduates. The effectiveness of ontological analysis as a didactic tool with specific examples is demonstrated.

1. Introduction

The transition to a two-stage system of training bachelor - master revealed a didactic problem of the relationship between applied and theoretical. Bachelor - a technical specialist with a fairly wide range of technical skills. As an architect, he participates in the development of project documentation. Master - a specialist with systems thinking skills. As an architect, he can develop concepts for various projects. This can be confirmed by the presence in the standard of the new generation of the Federal State Educational Standards FGOS 3++ competence «UK-1. Able to carry out critical analysis of problem situations on the basis of a systematic approach, to develop a strategy for action» [1]. Thus, the difference in training levels is not quantitative, but qualitative. Therefore, in the opinion of the authors, the main task of training in the magistracy is mastering the skills of systems thinking necessary for the transition to the next level of mastering specialty.

Let us consider in more detail what the critical analysis of problem situations means. Psychologist Diane F Halpern gives the following definition of critical thinking «Critical thinking is the use of those cognitive skills that increase desirable outcome. It used to describe that is purposeful, reasoned, and goal directed – the kind of thinking involved in solving problems, formulating inferences, calculating livelihoods, and making decisions, when the thinker is using skills that are thoughtful and effective for particular context and type of thinking task» [2]. The basis for critical thinking is cognitive skills. Cognitive skills – is skills that use concepts and logical constructions. Cognitive skills in comparison with visual-action skills and graphical-language skills, customary for architects, is a later stage in the development of thinking. In the context of the formulated problem, this is the difference between the visual-language skills of the bachelor and the cognitive skills of the master. This is supported by Le Corbusier’s famous statement that architecture is not a profession, but a style of thinking.
However, the nurture of cognitive skills in architects is hampered by the fact that architecture, being a synthetic discipline, comes into contact with many other scientific disciplines, borrowing their conceptual apparatus. As a result, the conceptual apparatus of architectural science itself suffers. The methodological weakness of the conceptual apparatus of architecture is convincingly shown in the work of N.P. Ovchinnikova [3]. This is even more true of landscape architecture, which interacts with even a wider range of scientific disciplines than traditional architecture. Thus, the problem of the nurture of cognitive skills among undergraduates enrolled in the specialty «landscape architecture» is not only relevant, but also complex.

A significant contribution to the study of cognitive skills was made by the Soviet psychologist L.S. Vygotsky [4], who supposed that the study of systemically organized scientific knowledge contributes to the nurture of cognitive skills. Systematically organized scientific knowledge is available in any textbook, and the study of textbooks is an indispensable part of the educational process. But this is a passive way for nurturing the cognitive skills. Today, active educational technologies are needed. Consider modern techniques that can nurture cognitive skills.

One of the current trends is the widespread introduction of information technology. The introduction of information technology is impossible without preparing the environment in which the technology operates. Preparation consists in the formalization and specification of the subject area, i.e. in creating a domain model suitable for use in information technology. In the opinion of the authors, these technologies form a «digital» style of thinking even more than the final result of the introduction of information technologies, which predetermines their significance. One of the technologies for the description and formalization of the subject area is ontological analysis. The modern interpretation of the term «ontology», not a philosophical, applied, is formulated by T. Gruber: «Ontology is the exact specification of conceptualization». «Conceptualization» means «an abstract, simplified view of the world that people use to achieve a certain goal» [5]. The essence of ontological analysis is to highlight the basic concepts of the domain and to establish the relationship between them. Ontological analysis is the modern active technology for the formation of cognitive skills. According to Russian standard GOST R 57297-2016, ontologies can have a hierarchical structure: ontologies of upper levels, ontologies of basic subject areas, ontologies of subject areas, applied ontologies [6]. When using ontological analysis in the educational process, we can talk about applied ontologies within the chosen scientific topic of master's thesis.

Currently, the use of ontologies in the educational process is developing in two directions: the analysis of curricula and programs using ontologies, the introduction of ontologies directly into the educational process. An example of the analysis of the curriculum can be found in the article I.Yu. Shpolyansksaya and I.I. Miroshnichenko [7]. Representatives of the second direction even created a new term “ontological training”. Examples of the use of the ontological approach to learning P Buitelaar, P Cimiano, B Magnini [8], as well as A Maedche, S Staab [9]. Ontological learning is based on technology Semantic Web and is designed to train knowledge engineers. Paul Butelara et al. Defines the concept of ontological learning «Ontology learning is inherently multidisciplinary due to strong connection with Semantic Web witch has attached researchers from a very broad variety disciplines: knowledge representation, logic, philosophy, databases, machine learning, natural language processing, image processing, etc.». Previously, the authors analyzed the process of introducing computer technologies into the practice of architectural design and concluded that in the future the architect will need the competence of a system analyst [10].

Another advantage of ontological analysis is that it is a kind of system analysis. The systems approach, about which architects like to talk about, is «the scientific method of knowledge, which is a sequence of actions to establish structural links between variables or permanent elements of the system under study» [11]. Thus, the use of ontological analysis in the educational process will allow us to purposefully form the competence of UK-1 of the standard FGOS 3 ++ about which it was mentioned above.

Thus, the significance of ontological analysis for the training of architects is as follows: ontological analysis is a type of system analysis, ontological analysis is useful for the formation of critical and
conceptual thinking. And the development of conceptual thinking is very important for architects who are accustomed to the visual-figurative style of thinking. We demonstrate the prospects of using ontological analysis in the educational process.

2. Method

For the practical implementation of ontological analysis, various standards have been developed, in particular, the IDEF5 ontological analysis standard [12]. According to the standard, the result of the process is an ontological model, which includes two components: a glossary containing the basic concepts (objects) of the subject area with their characteristics and a graphical diagram reflecting the relationship between the concepts (objects). The connections between objects in the IDEF standard are rich and diverse. Authors prefer to use a simpler scheme that includes several types of connections: a connection is «is a subtype», a connection is «consists of», a connection is «converted to» (such connections are called rules or processes). Typical schemes are built on the basis of these connections: a «classification» type scheme – figure 1, a «composition» type scheme – figure 2.

![Figure 1. Classification chart](image1)

![Figure 2. Diagram of the composition (structural)](image2)

The third type of charts "is converted to ..." shown in figure 3. Such diagrams are also called rules.

![Figure 3. Entity A is converted to entity B using rule P](image3)

Using a limited number of schemes is convenient for learning purposes and allows you to quickly form cognitive skills. The presence of a graphic component is valuable for architects who are used to the visual presentation of their ideas.

Further, according to the standard, before starting the study, it is necessary to determine the purpose of the study, its scope and point of view. This is done because the point of view determines the «perspective», under which the researcher analyzes the system. In architecture, they talk a lot about the systems approach, and the realization that the research point of view determines the characteristics of the system under study is very important for the future architect.

The task of performing an ontological analysis of the subject area is given to undergraduates of landscape architects during second semester of the course «Methodology, Methodology and..."
Presentation of Research». The task of performing an analysis is formulated as follows: conduct an ontological analysis of the subject area of his dissertation research. The results are presented in the form of ontology in IDEF5 notation. The ontology created by the undergraduate lies in public discussion.

3. Examples

Next, the results of the task on creating the ontology of the domain will be presented (for simplicity, we will give only a graphical relationship between concepts, without a glossary). It is important to note that the diagrams characterize the understanding of the undergraduate at this particular point in time. And work on the correct meaningful interpretation should be made in the course of the educational process.

![Diagram of landscape framework and related concepts](image-url)

**Figure 4.** Landscape framework and related concepts. Undergraduate A.K.

Figure 4 shows the graphical part of the ontology, which demonstrates what content the undergraduate invests in the concept of «landscape framework». Relations between concepts allow two interpretations: as a classification diagram and a composition diagram. The undergraduate chooses a composition chart that answers the question «what does it consist of». In the diagram, the undergraduate identified a fairly large number of concepts. At the lower level, the same objects are used: trees, bushes, lawns, but this is due to the possibilities of the graphical representation of concepts. In the glossary, object types are classified according to the definitions [13].

In general, this suggests that the undergraduate prevails practice type of thinking and well-expressed cognitive skill - ability to systematize. At the same time, the model proposed by the undergraduate is not very suitable for the critical analysis of problem situations. Thus, the task
performed on ontological analysis allows you to accurately establish thinking skills and ways for further individual work with the undergraduate.

Figure 5 shows the graphical part of the ontology, showing the relationship between concepts in the field of urban identity, beatification and identity. On the scheme, the undergraduate uses all the basic types of connections between concepts allowed by the standard. The urban identity, according to the undergraduate, includes («consists of») the landscape, climate, unique city buildings, a unique urban layout, the history of the city. Branding includes («consists of») style and identity. With the help of style, you can convert a typical beatification in the unique one. The style has the following varieties: constructivism, classicism and other styles.

In general, the ontology built by the undergraduate has a rich internal structure and contains a variety of semantic connections between concepts. In this case, the undergraduate demonstrates not only the developed skills of conceptual thinking, but also builds a model of the subject area, which includes a variety of relationships between entities (objects) of the subject area. There is also no doubt that the dynamic connections identified by the undergraduate can be used for critical analysis. In general, we can conclude that the undergraduate has the competence of UK-1 «It is able to carry out a critical analysis of problem situations on the basis of a systematic approach, to develop a strategy for action».

![Figure 5. The relationship of concepts in the field of identity. Undergraduate E.T.](image)

4. Conclusion

Earlier (in the introduction to the article) the importance of using ontological analysis in the educational process was justified from a theoretical point of view. The importance of ontological analysis was shown not only for the formation of one or another competence, but also for the formation of critical and conceptual thinking as the basis for the formation of other competencies. Further, using concrete examples, the possibilities of ontological analysis were demonstrated for
assessing not only the generated competence, but also the assessment of the thinking style of each particular undergraduate.

By their own recognition, undergraduates' task of creating an ontology of the subject area really creates the basis for project and research activities. When grading for the assignment, the number of terms in the ontology is taken into account, first, the number and variety of connections between the terms.

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