



Specific Nature of Spatial Awareness Formation of the Bachelor of Technical Higher Education Institution of Ukraine During the Basic Course

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Abstract: A formed spatial awareness is one of the main professionally important quality of a young professional, a graduate of Technical and Vocational Education and Training (TVET) and higher technical education institutions. The carried out analysis of graphical preparation in the process of school studying has allowed to ascertain that enrollees of basic technical specialties are prepared not at sufficient level, the spatial awareness is formed at a low level. The shortlisting of future students on the ground of the availability of elementary spatial awareness is not conducted. The formation of spatial awareness of students during the basic course in higher technical education institutions of Ukraine is rested exclusively on instructors. As a result of the literature sources and normative documentation analysis, we have developed a structural-stage model of the process of spatial awareness formation of a bachelor of higher technical education institutions which includes the initial, basic and professional stages. There were defined problems in the first stage of training at the level of basic knowledge of the spatial awareness, and was suggested to begin studying with consideration and solving of problems on the plane with the subsequent transfer of the solution to the spatial model. The transfer to the inverse process can be accomplished only after full understanding of the interrelation of the carried out geometric actions and learning the techniques and methods of solving metric and positional problems with two and three-dimensional figures. A logframe of classes conduction and measures for its realization have been developed. Carried out experimental investigations in regards to application of the specified approach in the training process have made it possible to increase the level of formation of the basic level of spatial awareness at the beginning of training.

Keywords: Spatial awareness, stages of formation, descriptive geometry, engineering graphics, structural-stage model, technical and vocational education

1. Introduction

The modern system of Technical and Vocational Education and Training (TVET) in education institutions of Ukraine is intended to create appropriate conditions for the competent specialist training, oriented towards constant professional development and self-improvement, which will, in the future, ensure a high level of competitiveness, professional mobility, professional activity efficiency, career development and realisation of personal potential (The Law of Ukraine №1556-VII - 392-IX "On Higher Education", 2020).

In the process of studying in Technical and Vocational Education and Training (TVET), as well as in higher technical education institutions, the future bachelor should acquire certain professionally important qualities (PIQ) that would cater to the needs of the modern labour market. Our expert poll (questionnaire of experts in the field of technical education and employers of technical enterprises) and processing of reference documentation (Dictionary of Occupational Titles, 2004, Artemenko, 2017) allowed determining the most significant PIQ for a bachelor of a technical higher education institution as a future specialist. Analysing the obtained results, it was discovered that a bachelor should have the following professionally important qualities (according to experts in %): numerical abilities - 95%; well-developed spatial awareness - 91%; inventiveness - 84%; creativeness - 79%; purposefulness - 73%; willingness to continuously obtain new knowledge - 68%.

The second most important PIQ for a bachelor of a higher technical education institution is a fully formed spatial awareness. Spatial awareness as a type of mental activity that provides the formation of spatial matrixes and their handling in the process of practical and theoretical problems solving (Rusynova, 2012), as well as gaining its development throughout the course of training of a future technical specialist (Yankiv, 2016).

Formed spatial awareness has a significant impact on the following future specialist aspects (Artemenko, 2018):

- i) reading graphic data and its processing, models building;
- ii) enhanced capability of analytical activity;
- iii) ability to predict the result of technical activities;
- iv) determine out-of-the-box solutions in the process of technical activity.

Provision of initial, mainstay and background of the development of spatial awareness is a very important task that should be carried out before the beginning of the study in a higher education institution. Theoretically speaking, the subject "Figurative Arts" is responsible for the development of spatial awareness in secondary schools of Ukraine (Bielkina, 2017). The main objectives of the course are the development of associative and conceptual thinking, awareness, fantasy, memory, artistic taste and creativity. Nevertheless, very little attention was paid to spatial thinking in training materials. In particular, only in the sixth grade the section "Form in the figurative arts" (14 hours) is stated, in which 8 hours are allocated for "Development of logical thinking, the ability to generalise, simplify and identify the design, the volume of the form". Hence, we can make a conclusion that the specified object has nothing in common with the development of spatial awareness. The concept of "volume" is studied in fifth grades during math classes (Denisyuk, 2011). For illustration, drawings of a parallelepiped and a cube are provided.

In order to clarify the impact of the fact that less attention is paid to the formation of spatial awareness in junior school, we conducted an ascertaining experiment - students of seven secondary schools (Kropyvnytskyi), with different specialisation, were offered to name the body represented. The card illustrated drawings of a parallelepiped and a cube projected not in the same way as in the textbook; 80% of the students did not recognise the parallelepiped and the cube. The results of the experiment make it possible to say that in junior schools of Ukraine the spatial awareness of students is not formed. In the senior school of Ukraine, during math classes, students study the section "Stereometry" (Mathematics Curriculum, 2012). It helps students to recognise spatial shapes, the mutual arrangements of straight-lines and planes, and learn formulas for calculating their volumes and lateral areas. In 10th and 11th grades, 51 hours per year are assigned to this subject. Besides, the program also includes the section "Coordinates and vectors".

In our opinion, this is not enough to master at least the basic spatial awareness skills. The absence of the "Drawing" subject, in most secondary schools in Ukraine, deprived students of the initial knowledge of spatial awareness. Therefore, it can be safely assumed that the enrollees of the basic technical specialities of higher education institutions of Ukraine do not possess the spatial awareness skills. The shortlisting of future students upon the availability of basic spatial awareness skills was not conducted.

1.1 Analysis of Recent Research

There is a commonly held belief that spatial awareness skills are fixed - whether you are a spatial thinker or not. According to our reckoning, such statement is false. Spatial awareness consists of many skills, which is why it is possible to succeed in certain aspects of your future professional career. Most important is identifying that spatial awareness skills can be improved by practice (Hedzyk, 2011, Rusynova, 2012, Livshic, 2012). The development of spatial awareness can be divided into two categories—spatial awareness at school and spatial awareness of students - future bachelors. Skoriukova (2017), over the course of five years, conducts an assessment and examines the

development level of spatial awareness of enrollees and students of technical specialisation and introduces the concept of zero control.

In the course of the research, it was discovered that the number of first-year students who have coped with the zero control task and who require spatial awareness elementary skills for the period from 2012-2013 to 2016-2017 academic years does not exceed 20%. Such a low index is evidence of the fact that there is no graphic preparation at school. For this reason, the task that faces the instructor is in a short span of time to increase the development level of spatial awareness of the student in the process of descriptive geometry training.

Currently, in the methodology, there exists a classical approach to this matter. The mainstay of such approach is to study the spatial objects mapping rules (octants, points, straight-lines, planes) in a plane using the Monge method (Monge, 1947). Therein, all drawings are considered as two-dimensional models of corresponding spatial objects (Babenko, 2008; Mykhailenko, 2013; Mahopets, 2014). This approach yields meaningful results on the condition that student goes through all stages of the process responsibly. If for some reason, one "link" in this "chain" does not work out, then the further process of understanding becomes problematic. Sasiuk (2015) also notes that large numbers of students do not possess sufficiently developed spatial awareness at the initial stage of the study. Textbooks are not easy-to-learn because the material is overloaded with explanatory graphic illustrations and descriptions. He emphasises that in order to activate and develop the logical and graphical mental capabilities and its spatial awareness possibilities in the study process, some changes to the traditional method of the course teaching are necessary.

As can be seen from the above, the initial formation of future bachelors' spatial awareness utterly depends on the approaches and methodology of graphic subjects such as "Descriptive geometry", "Engineering" and "Computer-aided engineering system (CAE system)". First and foremost, spatial awareness was formed during the study of the theoretical background of simple shapes projection (point, straight-line, plane, surface), their interaction, in other words, the section "Descriptive geometry". Without this, any analysis of the details will not be fully-featured and comprehensive. In the first stage, it is possible to decompose the part into simple elements. Although, plotting the interaction of these elements (intersection, merger, visibility) requires not only spatial awareness but also knowledge of descriptive geometry.

Smetankin (2015) believes that the key of importance in "Engineering and Computer Graphics" course was taken by the conclusive mastery and consolidation of techniques that students need to create images during drawing interpretation. In classes, students study the techniques of a detail analyses: its imaginary division into those geometric bodies of which it consists, and the selection of all its elements (tabs, slots, orifices, etc.). Yatsyshyn (2016) proposes the following methodology for preparing future instructors of "Figurative Arts": it was recommended that the study of drawing should be started with a closer look at the scientific foundations of "Descriptive geometry", with the use of figurativeness in the spatial representation of geometric shapes and their projections. Special attention is given to the operation of models point, straight-line segments, planes in space, objects and transformation of these elements into appropriate projections. It is the author's opinion that, this technique accelerates the process of formation and development of students' spatial awareness, the capability of free-and-easy operation of spatial matrixes.

But the limitation of point, straight-line, and plane modelling is not enough to develop a full-fledged spatial awareness. It is necessary to overspread the modelling with regard to solid of revolution and ruled surfaces as derivatives of a straight-line segment combination. Unfortunately, though, in recent years, the subject of "Descriptive geometry" is being represented as a condensed version in higher education institutions, and this was also considered to be mistaken (Livshic, 2012, Yankiv, 2015, Anisimov, 2019). For example, Leopold (2005) points out that, in recent years, the importance of "Descriptive geometry" has been significantly reduced in many engineering curricula. As a result of computer technologies and CAE system development, many engineering faculties have a view that there is no longer a need for descriptive geometry. Descriptive geometry must be replaced by the study of CAD systems.

Such development leads to a lack of opportunities for spatial awareness of students of technical specialisations. But, at present, the situation shows that knowledge of descriptive geometry is even more necessary than before. Other researchers agree with this as well. Yankiv (2016) points out that the truth of students graphic training matter is not only in the lack of concordance between secondary and high schools, but also in reducing the number of academic hours for studying general technical disciplines while maintaining the necessary scope of knowledge, skills and experience for students to master, and results in the fact that part of the course is taught and learned only at the level of concepts. Ten (2012) believes that computer modelling algorithms (PowerPoint lecture series), CAE system guidance manuals, didactic games course, creative assignments and didactic material: layouts, visual explanations for obligatory tasks, lecture material, and submission of creative assignments for home study can trigger the spatial awareness development to a full extent and release the student from manual drawing operations.

In general, this approach is future-oriented, but in our opinion, lecturing in any subject requires interactive communication with the instructor. If a lecture is aimed only at showing illustrative material on screen without the student's personal work, it has no result. The "routine operation" of the drawing helps the student to understand the essence of the process without a hint from the CAE system application packages. Livshytz (2012) agrees with this statement, and he emphasises that the leapfrog over the independent manual performance of tasks aimed at the development of spatial awareness as a whole, in the future, during the transition to professional activity significantly reduces the skill of a bachelor as a specialist. That's why, at the initial stage of training, there is a need for the future

technical specialist, to broadly master the skills of manual performance of tasks with respect to "Descriptive geometry and engineering graphics" courses at the beginning of spatial awareness formation process. Upon realisation of the carried out works, it is necessary to proceed with the training and use of computer graphics and CAE system tools in the further technical specialists training.

By all means, the highest level of spatial awareness formation is mastering of CAE system application packages and their all-encompassing usage, Ozhha (2012) said that at the present stage of the science development, computer graphics is used in almost all scientific and engineering fields for clarity of perception and transmission of information. Its usage aimed at demonstration slides preparation is already considered to be a standard. The final outcome of computer graphics usage is an image or video clip that can be used for various purposes. All this is possible if the formation of spatial awareness at the basic level has already taken place.

The results of carried out analysis of the literature have made it possible to define that school graduates and students who begin their studies in higher education institutions barely possess spatial awareness knowledge and its formation should take place in the first year of study. For this reason, there is a need to develop and implement such approaches to learning the concepts and producing drawings that gradually, without causing students negative impressions, gave the opportunity to obtain a basic level of spatial awareness formation. Purpose of work: detection of specific features of spatial awareness formation of bachelor of higher technical education institution of Ukraine at the initial stage of training and appliance of a new approach towards formation of the necessary basic level of spatial awareness.

To achieve this goal, we solved the following tasks: to analyse the state of spatial awareness formation of the bachelor of higher education institution at the beginning of the study and to determine its level; to develop a structural-stage model of the spatial awareness formation process of the bachelor of higher technical education institution; to examine the existing approach towards the development of spatial awareness at the beginning of study and to identify its disadvantages; to ground a new approach to ensure the basic level of formation of the student's spatial awareness at the beginning of study; to conduct experimental research to determine the impact of the proposed approach upon the successful formation of students' spatial awareness.

1.2 Structural-Stage Model of the Spatial Awareness Formation

Based on the analysis of literature sources, it was revealed that at the current stage of education development in Ukraine, school education does not provide in full the formation of spatial awareness of enrollees of the higher technical education institution. Though spatial awareness is one of the main professionally important quality of a future specialist. The carried-out analysis made it possible to develop a structural-stage model of the spatial awareness formation process of a bachelor of higher technical education institution (Fig. 1). The model includes the initial, basic and professional stages of the spatial awareness (SA) formation.

At the initial stage of formation (school education), it is necessary to: ensure the development of students' spatial awareness, which lies in the ability to form matrixes in three-dimensional space. Initially, it is useful to perform tasks such as "draw a triangle, circle, and quadrangle in such a way that the circle is to the left of the triangle and the quadrangle to the right". The next step is the exercises with three-dimensional objects (LEGO constructor). While carrying out these tasks, the student is able not only to analyse three-dimensional objects, but also to redesign, transform and improve them. Then you proceed to the construction of spatial figures, consisting of straight-lines or planes.

At the basic stage of the student's spatial awareness formation it is necessary to: acquire graphic modelling skills; perform two types of images - on the plane (drawing in projections) and in three-dimensional space (axometric images); understand the features of the mutual arrangement of geometric bodies and surfaces (visibility of elements, intersections), master techniques and methods of their construction; to acquire basic knowledge of CAE system operation, to transfer into them the imagined images and to build two-dimensional drawings, as well as three-dimensional models.

At the professional stage of formation it is necessary to provide the following skills: research of the machines' mechanisms, design of their systems, formation of the processes of their work in the imagination, carrying out drawings of machines' and mechanisms, schemes and graphics; design of machines and mechanisms and their elements, formation of the operational process and design features of the interacting elements in the imagination; in-depth study of the capabilities of CAE systems, formation of complex geometric shapes in the imagination, the construction of three-dimensional models of assembly drawings; fast formation, in the imagination, of machines' mechanisms and their elements, their operation process, the ability to reproduce these images in CAE systems, the construction of their models and drawings.

Analysing the model represented in Fig. 1, we can see that the basic subject in the higher education institution aimed at ensuring the formation of the basic level of spatial awareness formation of the first-year students is "Descriptive geometry". This subject provides the basis for creating and understanding drawings and three-dimensional objects and helps to develop the possibilities of spatial visualisation, which is also confirmed by Babenko (2008), Mykhailenko (2013), Mahopets (2014) and Koziar (2016).

In future, a course of “Engineering and Computer Graphics” is introduced. This course has exclusively applicable nature and is based on the course of “Essential geometry”. Due to the fact that the basis of descriptive geometry is spatial awareness - this subject automatically is considered to be among incomprehensible and complex subjects of the first year of higher technical education institution of Ukraine.

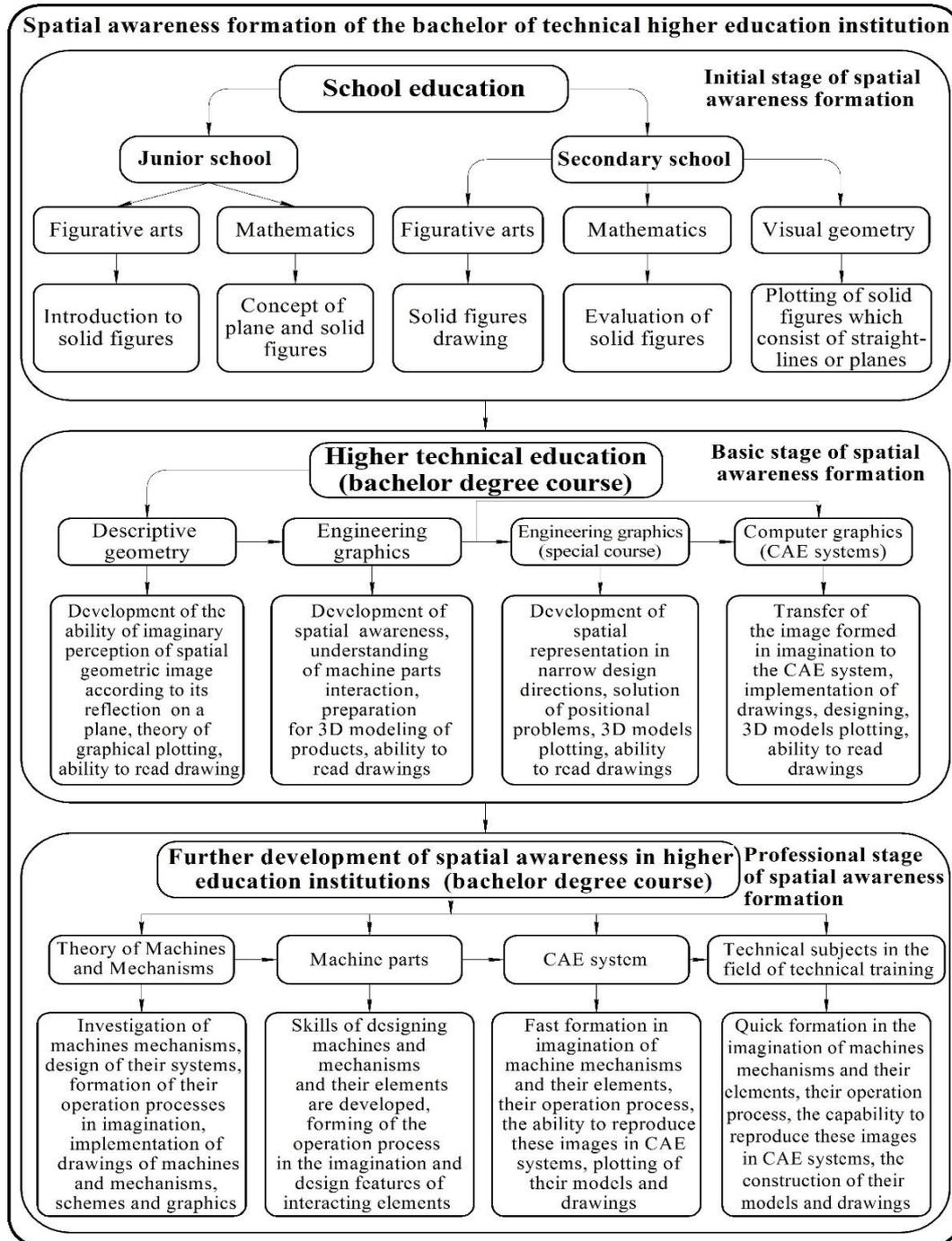


Fig. 1 - Structural-Stage Model of the Spatial Awareness Formation of Bachelor of the Higher Technical Education Institution

2. Methods

It is considered that at the beginning of the study the student should already have the initial level of spatial awareness formation so the generally accepted approach during tasks performance regarding first topics of the course "Descriptive geometry" is, first of all, solving the problem in space: imaginatively draw straight-lines, planes or surfaces, imagining the way of solving and its results, and also solving in projections. Only after the problem will be solved in mind, it is a necessity to start solving it on the plane.

Nowadays, the disadvantage of this approach is that the minimal or lack of initial level of spatial awareness was not considered. This, on the other hand, greatly affects the student's ability to understand the basics of "Descriptive geometry" at the beginning of study, and going forward, in-depth study of applied subjects. Therefore, at the beginning of the study, it is necessary first of all to teach the student to solve problems on the plane, and then to transfer the solution to the spatial model, and only after complete understanding of the relationship of carried out works to move towards the inverse process. We have developed a logical-structural scheme of classes conduction during the first four weeks of the course "Descriptive geometry" (Fig. 2), which implements the proposed approach to the study of the first four topics of the course "Descriptive geometry".

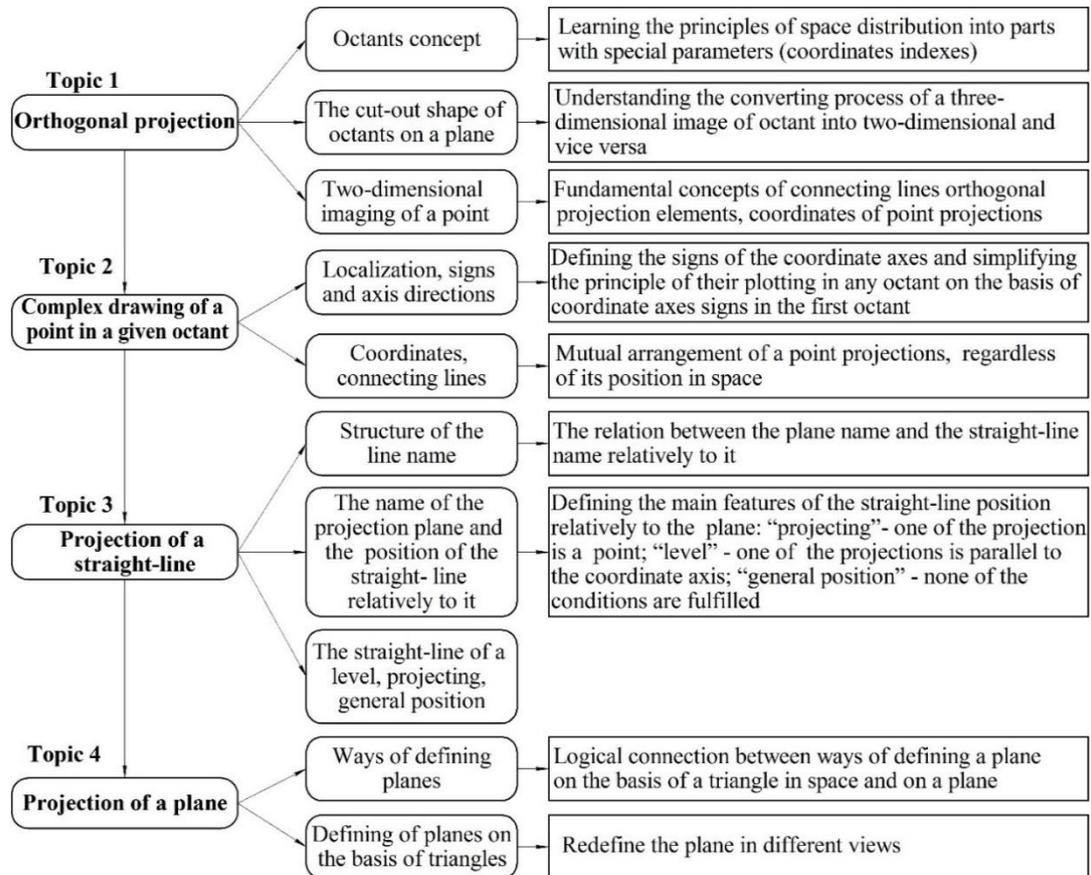


Fig. 2 - Logical-Structural Scheme Of Classes Conduction

In furtherance of the proposed approach, we suggest to consider some examples of tasks for the step-by-step formation of the student's spatial awareness at the beginning of study.

The first lesson of the descriptive geometry of classical course (Mahopets, 2004, Lus, 2008, Krivtsov, 2019) begins with orthogonal projection. The concept of octants is introduced, in other words, the division of space into three mutually perpendicular planes (Fig. 3).

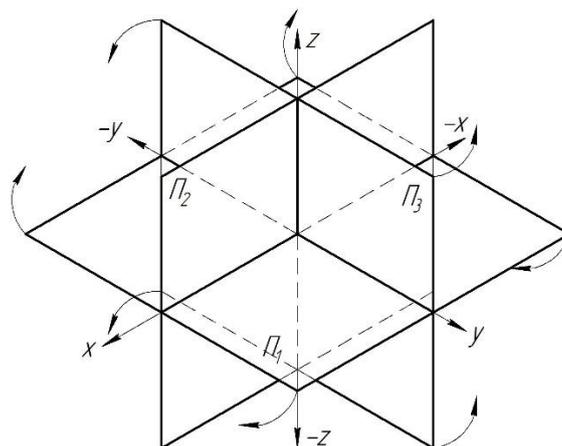


Fig. 3 - The Spatial Model and Its Deployment to the Plane

The next step is to convert the spatial image of a point in one of the octants into a two-dimensional image. This is implemented by means of horizontal and profile planes rotation around the respective axes to coincide with the face plane. The projecting rays in the drawing developed view are reflected as connecting straight-lines. As a rule, a cut-out shape of the first octant does not cause particular difficulties for a student. But the cut-out shape of other octants already requires a spatial awareness, which the student has not formed.

The construction of a complex drawing of a point in a given octant (or at given coordinates) begins with the construction of the axes of coordinates belonging to this octant (Fig. 4). The planes of projections, which are included in this octant, can coincide and change places when deployed. Accordingly, the coordinate axes, depending on the sign, also change their position and direction in comparison to the first octant.

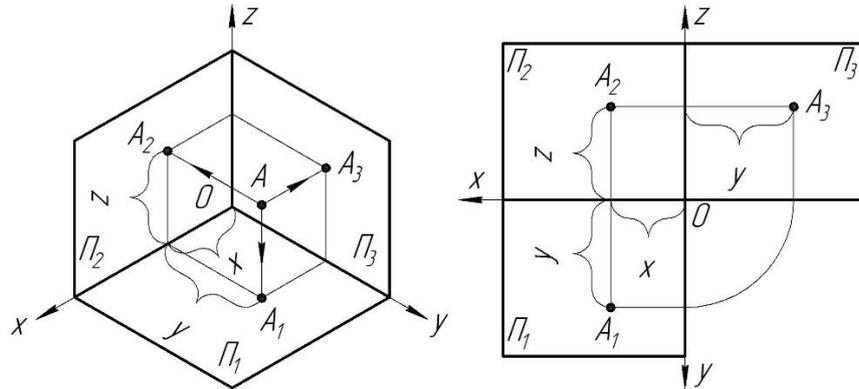


Fig. 4 - Spatial Model and Complex Drawing of a Point, Which is Located in the First Octant

To simplify the construction of point projections in any octant for the student whose spatial awareness is not yet formed, we propose the following approach:

- i) it is necessary to remember well the locations, signs and directions of the axes for the first octant deployed, paying special attention that they are all positive;
- ii) the construction of a complex drawing of a point in a given octant begins with the direction of the axes, if the coordinate sign is negative - the axis is directed in the opposite direction to the positive value of the first octant (Fig. 5).

The construction of the point projections begins with a front A_2 which has coordinates $(x; z)$. From it, on a vertical connecting straight-line will be located horizontal projection of a point A_1 with coordinates $(x; y)$. Student's attention should be paid to the fact that A_2 and A_1 are always located on the same vertical connecting straight-line because they have the same coordinate - x . The profile projection of the point A_3 $(y; z)$ is sought on the horizontal connecting straight-line with the projection A_2 so far as their mutual co-ordinate is z .

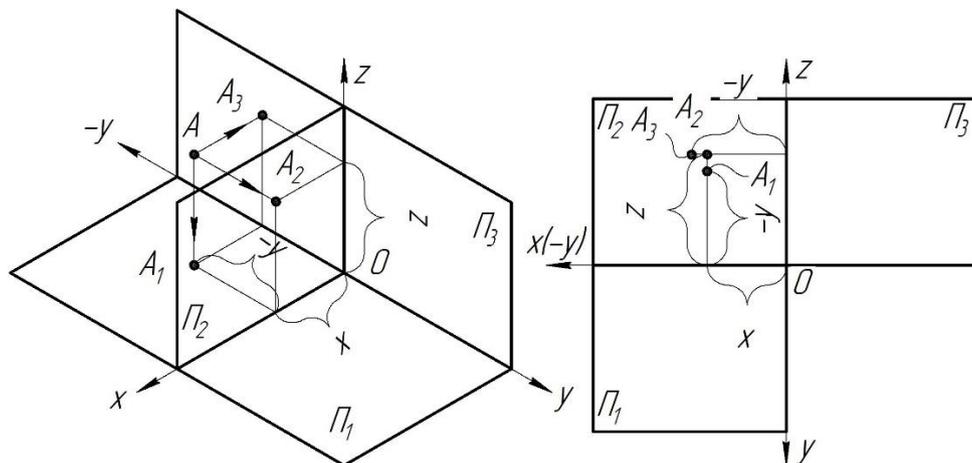


Fig. 5 - Spatial Model and Complex Drawing of a Point Located in the Second Octant

The next topic of “Descriptive geometry” is the projection of a straight-line. Let’s consider the case of the straight-line location relative to the projection planes. The structure of the straight-line name, which is located relative to the plane of projections, already provides a clue regarding its location. That is, the name of the plane and the position of the straight-line relatively to it. Showing students a straight-line in different positions relatively to the projection planes, it should be emphasised that a straight-line which is parallel to the projection plane encloses in the name the definition of this plane and the addition of "level". A straight-line that is perpendicular to the plane in the second word of the name has "projecting". A straight-line that is neither parallel nor perpendicular to any of the planes - the general position. Summarising this rule, it should be emphasised that this peculiarity in the title applies to other figures, in particular planes.

Building a complex drawing for the abovementioned straight-lines does not cause much difficulty for students at the beginning of study, in comparison to the construction of a straight-line that is in different octants already causes considerable difficulties and requires initially formed spatial awareness (Fig. 6). To solve such problems, the proposed approach (the way of the solution can be seen from the figure) not only makes it possible to obtain the result on the plane at the given coordinates, but also to obtain a spatial model afterwards.

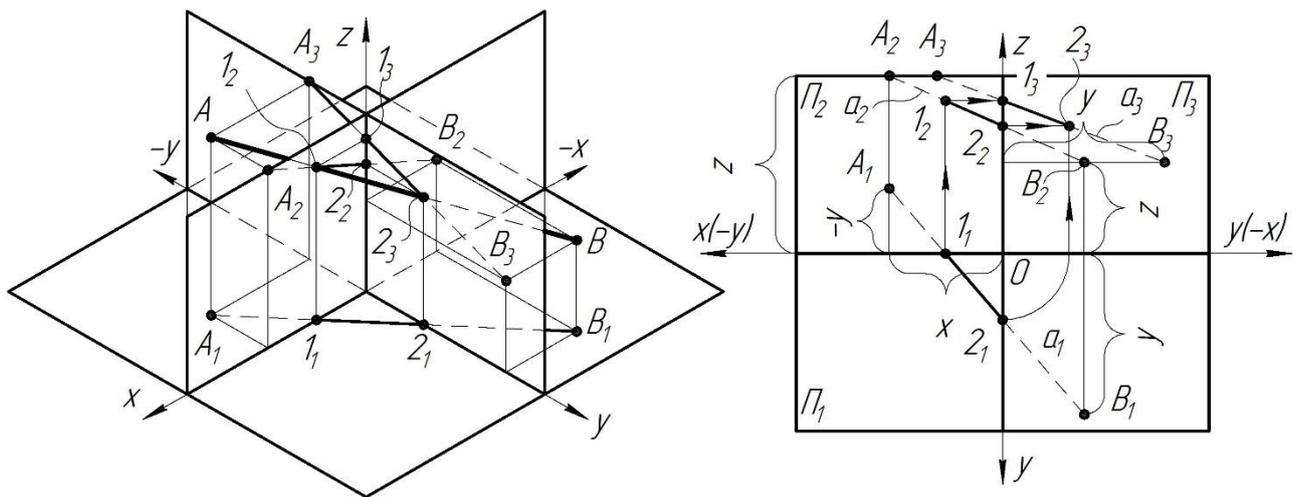


Fig. 6 - Spatial Model and Complex Drawing of a Straight-Line of General Position, Which is Located in Different Octants

While considering ways of defining planes with different geometric shapes, it is necessary to start with defining planes by a triangle, as most understandable to students. Changing, step-by-step, the view of the triangle, it is possible to explain tasks of the plane straight-lines, which are intersected by point and straight-line, parallel straight-lines (Fig. 7). In this manner, as long as simple tasks are fulfilled during the first four weeks of study, the initial spatial awareness will be formed, which will be further improved in order to reach basic level.

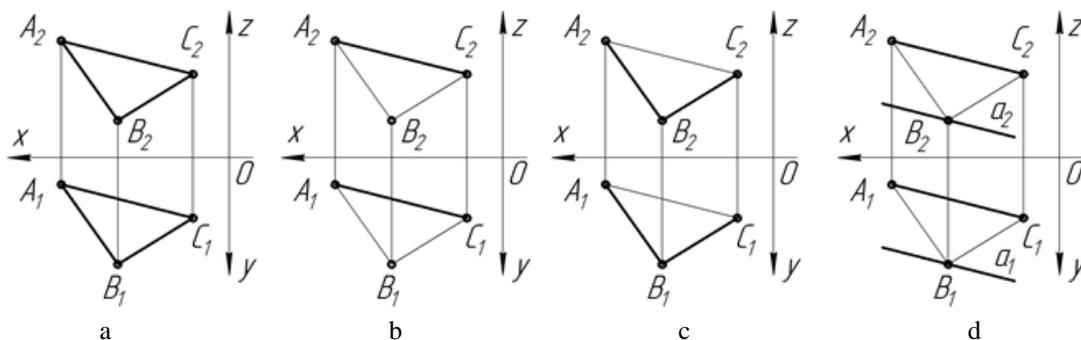


Fig. 7 - Methods Of Defining Planes: A – Triangle; B – Point and Straight-Line; C – Straight-Lines, Which Are Intersected; D – Parallel Straight-Lines

3. Results

With the purpose of establishing the actual state of spatial awareness formation of a student of higher technical education institution at the beginning of study after the application of the proposed approach, we conducted experimental researches.

The objectives of the experimental research:

- i) To estimate the level of spatial awareness of a student of higher technical education institution after applying the proposed approach;
- ii) To analyse the state of spatial awareness formation of a student of the higher technical education institution.

Experimental work aimed at checking the effectiveness of the spatial awareness formation conditions of a student of higher technical education institution was carried out during 2017 - 2019 on the basis of the Central Ukrainian National Technical University (CUNTU) and Flight Academy of National Aviation University (FANAU). The research involved first-year students of technical specialties with education qualification level - bachelor. For the experiment, there were created three groups of students with a total number of 60 people. The groups were subdivided into subgroups. In the first subgroup, the classes were conducted according to the classical approach, in the second one according to the proposed one. Conditions of the experiment are an educational process. The knowledge assessment was implemented after passing the first four topics of the course "Descriptive geometry".

Students were asked to answer six theoretical questions and solve four practical tasks. If the student has answered all the tasks – he/she has a high level of spatial awareness formation at the basic stage of formation; in the case of 4 to 7 correct answers - average level (to improve it is necessary: to find the most common misunderstandings; if certain questions caused complications for most students - repeat this section; if the misunderstandings were distributed randomly - to conduct additional classes on the whole topic); if the student correctly answered only three or less questions - low (to improve it is necessary: to conduct additional explanatory work, practical training on all topics of the section).

On the basis of experiment results, the percentage of students with a high level of spatial awareness formation at the basic stage of formation according to the classical approach was 20%, the number of students with an average level of 35%, low 45%, according to the proposed approach was 28%, the number of students with an average level of 58% , with a low 14% (Table 1).

Table 1 - The Results of Experimental Researches of the Spatial Awareness Formation at the Basic Stage of Formation

Level of spatial awareness formation	Teaching methodology	Group A, male	Performance indicator, %	Group B, male	Performance indicator, %	Group C, male	Performance indicator, %	Average, male	Average, %
Low	Classic	8	40	10	45	9	50	27	45
	Suggested	3	15	3	15	2	10	8	13
Average	Classic	7	35	7	30	7	40	21	35
	Suggested	12	60	11	50	12	65	35	58
High	Classic	5	25	3	15	4	20	12	20
	Suggested	5	25	6	30	6	30	17	28

On the basis of the experimental researches results, it was possible to reveal that 86% of students showed a satisfactory level of spatial awareness formation according to the proposed approach. Along with this, the number of students with low spatial awareness decreased by 31%, with average increased by 23% and with high increased by 8%. The results of the experimental classes carried out according to the proposed approach made it possible to note a significant improvement in the formation of the basic level of spatial awareness regarding the sections of the course "Descriptive geometry" - "Orthogonal projection, point, straight-line, ways of defining planes". The proposed approach helps students to proceed to the next sections of the "Descriptive geometry" course by simplifying the teaching of basic concepts and consolidating the capability to proceed from a spatial representation of a condition and task solution to a representation on a plane and vice versa. Going forward, relying on the obtained results, it is planned to develop a new approach to teaching the following sections of the "Descriptive geometry" course.

In order to improve the educational process, it is planned to develop an adaptive educational system that will contain the following blocks:

- i) Designation of the level of spatial awareness formation of students at the beginning of study (entrance testing);
- ii) Designation of study path (selection of tasks, tests, tasks for self-examination at each stage of training);
- iii) Intermediate testing (during the transition between stages of training);
- iv) Final testing (determining the level of spatial awareness formation and recommendations).

4. Finding and Discussion

The basis of the mentioned research is the problem of a low level of preparation of students of technical specialties at the initial stage of study. Most of the preparation stages of the future specialist of technical direction are thoroughly considered, on the basis of which the structural-stage model of the process of the spatial awareness formation of the a bachelor of technical higher education was developed. Analysing the obtained model, we can say that school education is important in the formation of spatial awareness at the initial stage. Our conclusions are reflected in the works of foreign scientists.

Thus, Bimova (2019), points out that spatial awareness belongs among innate abilities. A person is born with a certain initially formed spatial awareness, which is necessary for everyday life. At the same time, especially spatial awareness is necessary in obtaining education in many directions, such as manufacturing engineering, aviation, construction engineering, design, ecology, medicine, etc. There have been carried a number of researches targeted at determination of whether the level of spatial awareness can be developed throughout life. It has been defined that this is possible and the time – periods for the best formation of spatial awareness have been identified. These time - periods are school education and initial education in higher education. If we focus on these two time – periods and intensify efforts in school, it is likely that the level of spatial awareness at the beginning of university studies will increase significantly. It is suggested that the school should pay more attention to the subject of stereometrics, and if it is impossible than during Math classes to conduct stereometrics workouts.

According to the analysis that we carried out, it can be seen that the level of spatial awareness of first-year students in the universities in Ukraine is quite low. This is also confirmed by multi-year researches of Skoriukova's (2017), who showed that only 20% of college enrollees have an initial level of spatial awareness. In such a situation, instructors need to form an initial level of spatial awareness in the shortest possible time and provide the basis for further development at a basic level. In such circumstances, it would make sense to introduce advanced methods of explaining the classical material of the "Descriptive geometry" course.

Alvaro-Tordesillas (2019) also shares our point of view. He notes that when entering the first year of university and beginning study of "Descriptive geometry", students with low initial training, feel disoriented, experiencing the complexity of the discipline, feel difficulties regarding further studying, understands that the classic teaching of a complex subject is unclear. That's why it is necessary to simplify the teaching methodology as much as possible by going from simple to complex. Introduce game-based techniques to motivate and encourage further study of the subject.

The carried out experimental researches made it possible to define that with the gradual entry of the student in the subject and providing an understanding of the inverse of the process of transition from flat image to spatial and vice versa, it is possible to obtain a rapid formation of the basic level of spatial awareness and ensure the promotion to the next level - professional. Since this research incorporates the basic concepts of the proposed methodology only on the first four topics of the course "Descriptive geometry". In the future, it is planned to develop a methodological framework on other topics of the course and grounding of approaches to their implementation.

5. Conclusions

On the basis of the carried-out analysis of literature sources and ascertaining experiment, it was determined that the enrollees of the basic technical specialties possess very low level of spatial awareness. The shortlisting of future students upon the availability of basic spatial awareness skills was not conducted. The formation of the students' spatial awareness at the initial stage of study in the higher technical education institutions of Ukraine is entirely entrusted to the instructors of higher education institutions. There has been developed a structural-stage model of spatial awareness formation process of a bachelor of higher technical education institution, which includes three interrelated stages: initial, basic and professional. There has also been developed logical and structural scheme of classes conduction.

In respect of the low level of students' spatial awareness formation, the classical method of teaching sections of descriptive geometry "Orthogonal design, Point, Direct, Methods of planes" in higher technical education institution does not provide a sufficient level of students' knowledge. Most of students have a low level of formation, which is 45%. In order to simplify the students' entry process into the subject overall, there has been considered simplified methods of teaching of the above-mentioned sections. There have been carried out experimental researches aimed at establishing the degree of material retention. The number of students who took part in the experiment (about 60 people each year) allows us to define the accuracy of the results.

As a result of carried out experimental researches, it was determined that in comparison with the classical methodology, the proposed approach showed a significant improvement in spatial awareness of the majority of students. The number of students with low spatial awareness decreased by 31%, with an average increased by 23% and with high - increased by 8%. Moreover, students of the average level of knowledge showed the most improvement.

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