Scientific and Methodological Approach for Organizing a Pedagogical Experiment to Evaluate the Efficiency of a Pedagogical System in Ensuring Quality Professional Combat Training for Future Tactical Aviation Pilots

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The article aims to develop a scientific and methodological approach for organizing a pedagogical experiment to test the effectiveness of a pedagogical system in ensuring the quality of professional training for combat flights of future tactical aviation pilots. This approach aims to evaluate the efficiency of the theoretical provisions of the pedagogical system for ensuring quality professional training and to implement them into the educational process of an aviation university in Ukraine. Additionally, this approach serves as a basis for further experimental research to determine the feasibility and application value of the specified pedagogical system. To test the pedagogical system's efficiency in ensuring the quality of professional training for combat flights of future tactical aviation, a pedagogical formative experiment with natural, partially modeled, real, and multifactorial conditions is proposed. The pedagogical experiment consists of three stages: the formative and ascertaining stage; the organizational and pedagogical stage; and the ascertaining and formative stage. It is recommended to assess each component of professional readiness for combat flights of future tactical aviation pilots separately, including cognitive, operational, motivational and volitional, as well as physical readiness. Each of these components is to be evaluated using its own methods. The proposed approach suggests that the efficiency of the pedagogical system in ensuring professional training quality for combat flights of future tactical aviation pilots should be tested through a multifactor experiment. The results of the experiment will help identify individuals with an unsatisfactory level of training in a separate component of professional training who require additional individual training sessions. The results of this study should be used to improve the training process of military pilots. For example, pedagogical experiments can be conducted based on the recommendations outlined in this article to test the efficiency of the pedagogical system in ensuring the quality of professional training. Furthermore, the proposed approach can be used to identify individuals who require additional training sessions to improve their professional readiness for combat flights.

Keywords: Military aviation, Cadets, Vocational training, Pedagogical experiment, Efficiency of pedagogical system, Research methodology.

Introduction

The quality of professional training for combat flights of future tactical aviation pilots depends not only on the efficiency of the developed pedagogical system but also on the perfection of the approach to verify the pedagogical system's efficiency to ensure the training quality. According to the methodological provisions accepted in the modern philosophy of science, any new research of phenomena, processes, and facts of reality, including pedagogical, should consist of two basic methodological blocks (levels) – theoretical (level of specific scientific methodology) and experimental (level of methodological technique of knowledge): at the first level, new scientific facts are created and generalized, new laws are formulated, and at the second level, scientific hypotheses are verified by testing in real conditions (Khrykov, 2018).

This logic of the pedagogical research structure is explained by the specificity and ambiguity of its object matter. First, it always includes people, which automatically relates such an object of cognition to social objects that are difficult and imprecise to study. Second, pedagogical processes are dynamic systems that are constantly changing. Third, pedagogical systems are so-called "non-linear" systems, meaning that when one of their elements changes, the others do not change proportionally but more complexly. Therefore, theoretical results of the study of pedagogical systems shall be reasonably and experimentally verified to ensure their usefulness and efficiency. At the same time, the results thus confirmed become useful and valuable not only from a heuristic point of view but also in terms of pedagogical practice.

In view of the above, the problem of developing a scientific and methodological approach to organizing a pedagogical experiment to test the efficiency of the pedagogical system in ensuring the professional training quality for combat flights of future tactical aviation pilots is relevant. The main purpose of this approach is to test the efficiency of theoretical provisions of the pedagogical system for ensuring the quality of professional training for combat flying of future tactical aviation pilots with a view to their further implementation in the educational process of an aviation university in Ukraine. In addition, this approach serves as the basis for further experimental research to determine the feasibility and application value of the specified pedagogical system.

The basis of our study, its procedural and orientation basis, are the theoretical scientific provisions set out in the works of Panasenko (2013), Tverezovska & Sydorenko (2013), Vlasenko (2014), Luhovyi & Yaroshenko (2014), Khrykov (2018), Kurylo & Khrykov (2013), and others.

Panasenko (2013) clarified the stages of the evolution of an experiment based on her study and highlighted the peculiarities of its implementation in current conditions. Tverezovska & Sydorenko (2013) substantiated in their research the essence, role, and importance of the pedagogical experiment as the main method of empirical research. Vlasenko (2014) studied methodological aspects of a pedagogical experiment and generalized recommendations for its organization, taking into account the specifics of the environment.

Important for the purposes of our study is the work of Luhovyi & Yaroshenko (2014), which systematizes and substantiates the conceptual and methodological foundations for designing

methods and tools for diagnosing educational outcomes in higher education institutions.

Certain methodological aspects of pedagogical experiments are summarized in the work of Kurylo & Khrykov (2013).

A detailed analysis of modern scientific developments has resulted in the conclusion that there is a significant theoretical contribution to the current issues of the organization of pedagogical experiments. However, there is a need to study the issue of organizing a pedagogical experiment in the field of aircrew professional training. The purpose of our study is to develop a scientific and methodological approach to the organization of a pedagogical experiment to test the effectiveness of the pedagogical system in ensuring the quality of professional training for combat flights of future tactical aviation pilots.

Methods

The interpretation of the experiment as a special empirical research method was proposed by Tverezovska & Sydorenko (2013). According to their research, a pedagogical experiment is "a method of research in which there is an active influence on pedagogical phenomena by creating new conditions that meet the purpose of the study" (Tverezovska & Sydorenko, 2013). A pedagogical experiment is a specially designed and implemented pedagogical process or system that includes new elements and allows for a deeper understanding of internal connections and relatively accurate accounting of the results of the changes made.

The main characteristics of a pedagogical experiment in a thorough manner include:

- Maximum isolation of the phenomenon under study from insignificant factors – the study of the phenomenon "in its purest form";
- Numerous repetitions of the process in rigidly fixed and controlled conditions with a clear possibility of its accounting and evaluation;
- Organized variations and combinations of various internal conditions to verify the results comprehensively.

It is an a priori statement that the design and organization of an experiment for a particular study is determined by its purpose. Within the latter, there are a number of criteria by which scientific experiments are classified and which are extremely important for choosing a specific methodology for our verification study:

1. Depending on the purpose of the study, a distinction is made between formative experiments, which involve the development of a new pedagogical approach according to the research hypothesis, and ascertaining experiments, which are performed to test the impact of a known factor under new conditions with different contingencies. This division is particularly characteristic of many recent psychological and educational works. Scientists emphasize the conceptual characteristics and differences of these experiments from experiments in other fields of knowledge, such as: a) the object is structured before becoming the object of study; b) multidisciplinary idealization; c) modelling and design elements; d) evaluation of data from the standpoint of the model idea and analysis of the consequences (Lavrentieva & Shyshkina, 2007).

2. Experiments can be categorized according to their conditions: a) natural experiments involve studying objects under normal functioning conditions; b) artificial or laboratory

experiments involve studying objects under artificial, "chamber" conditions, and model experiments involve conducting experiments with ideal images and quantitative dependencies between objects expressed through mathematical functions, equations, systems of equations and other abstract structures (Tverezovska & Sydorenko, 2013). The experimental testing of our pedagogical system was conducted under the natural conditions of the professional training of military pilots, in a higher military educational institution.

3. According to the type of interaction between the object and the means of research, there are conventional or classical experiments, wherein experimental means directly interact with the object under study, and modeled experiments, wherein an existing model of the object under study is used to test the hypothesis. In our case, we have an indirect model of the implementation of a pedagogical system for ensuring the quality of professional training for combat flights of future tactical aviation pilots, which partially gives our verification experiment the character of a modeled experiment.

4. Experiments can also be categorized based on the type of object and/or model under study. Mental or intellectual experiments involve the study of an imaginary model of an object while abstracting it from the influence of undesirable factors, while material or real experiments involve empirical research of a material object. In our work, we rely on the results of a real experimental study.

5. Finally, according to the number of factors controlled in the experiment that significantly affect the object of study (independent variables), we distinguish between single-factor experiments, wherein all factors except one in the experimental and control groups are identical and multifactor experiments, wherein two or more independent variables are tested, leading to factorial plans. We tested several independent variables in the study of the developed pedagogical system's efficiency.

The above criteria for dividing experiments do not exhaust the entire current list of approaches for their scientific classification. Therefore, we will analyze the ones that are most characteristic of pedagogical theory.

Based on the above, we propose to test the efficiency of the pedagogical system for ensuring the quality of professional training for combat flights of future tactical aviation as a pedagogical formative experiment (by study purpose), natural experiment (by performance conditions), partially modeled experiment (by the type of interaction between the object and the means of study), real experiment (by the type of object under study), and multifactor experiment.

A separate methodological basis for our verification study was the general program for studying the system of quality assurance of professional training of flight school cadets in the context of European integration by Plachynda (2014).

Results

The choice of this particular format of experimental research is based on its specific purpose and objectives. The tactical goal is to experimentally verify the efficiency of the developed pedagogical system to ensure the quality of professional training for future tactical aviation pilots. The strategic goal is to empirically verify the validity of the general hypothesis of our study on optimizing the organization, content, and methods of the process of professional

training for combat flights as a way to improve its quality.

The specific and applied tasks of the experiment are as follows:

- Introducing the developed model of the pedagogical system of ensuring the quality of professional training for combat flights of future tactical aviation pilots in the real educational process at the Ivan Kozhedub Kharkiv National Air Force University.
- Creating appropriate pedagogical conditions in the process of professional training for cadet-pilots (future tactical aviation pilots) of the Ivan Kozhedub Kharkiv National Air Force University who are participating in the experiment.
- Quantitatively and qualimetrically measuring the components of professional readiness of future tactical aviation pilots of the Ivan Kozhedub Kharkiv National Air Force University in the context of theoretical, physical, and simulation training (cognitive, activity, operational, motivational and volitional, physical and psychophysiological components) using a system of criteria, indicators, and levels developed by us based on specially selected complementary diagnostic methods.

Based on the set goals and objectives, the pedagogical experiment to test the efficiency of the pedagogical system for ensuring the quality of professional training for combat flights of future tactical aviation pilots should consist of three stages (Figure 1).

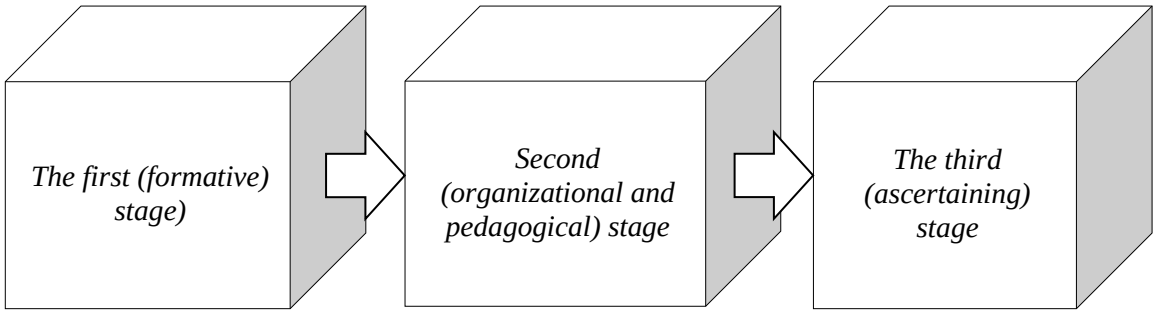

Figure 1. Stages of the pedagogical experiment to test the pedagogical system efficiency of ensuring the quality of professional training for combat flights of future tactical aviation pilots

As can be seen from Figure 1, the pedagogical experiment process consists of three stages:

1. The first (formative ascertaining) stage. At this stage, it is recommended to select the basis of the experiment and form two groups from the total number of cadets for the purpose of the experiment: an experimental group (EG) and a control group (CG). The first group will be directly exposed to the experimental impact during the study, while the second group will not participate in the experiment itself, but its results will be compared with the results of the first group to determine the extent of the impact, validate the results, and calculate the efficiency of the measures taken. The main characteristics of the experimental group should be:

- Age limits at the beginning and end of the experiment: 19-22 years;
- Gender: male (partially random selection related to the peculiarities of the military

pilot profession);

- All cadets have passed the initial occupational selection.

2. The second (organizational and pedagogical) stage. The content of this stage is the introduction of special pedagogical conditions for the functioning of the educational process in the experimental group of cadets, which will help improve the quality of their professional training for combat flights.

3. The third (ascertaining formative) stage. At this stage, the author's approaches, activities, and innovations introduced into the system of professional training for future tactical aviation pilots are quantitatively tested and evaluated to improve its quality. The experiment identifies the insufficient level of formation of certain competencies and conducts a formative experiment to improve these levels. It is recommended to measure each component of the professional readiness for combat flights of future tactical aviation pilots separately, which is summarized in Table 1.

Table 1. Components to be assessed in a pedagogical experiment to test the professional readiness for combat flights of future tactical aviation pilots

Component	Purpose of the assessment	The main methods used for the assessment
Cognitive component	Determines the accuracy and speed of tactical decision-making in rapidly changing circumstances and optimality of ideomotor reactions in a combat situation	R. Amthauer Intelligence Structure Test
Operational component	The practical training potential	-A simulated failure identification (in seconds) -Cadet's actions in case of a failure (in seconds) are analysed
Motivational and volitional component	1. Determination of the motivational complex of a personality as an indicator of satisfaction with the chosen profession of a military pilot 2. Determination of the content and expression of volitional qualities of cadets-military pilots on the basis of decision-making in difficult situations	-According to the diagnostic method of K. Zamfir (in the modification of A. A. Rean) -According to the diagnostic method of N. Ye. Stambulova
Physical component	It assesses the state of the main physical qualities to determine the overall performance of flight personnel, which in turn is the functional basis for professional performance; physical fitness determines the level of dynamic health"	A physical test (according to the method of R. M. M. Makarov) with the use of diagnostics of self-assessment of functional state by the "SAN" method (according to V. A. Doskin et al.)

So, as can be seen from Table 1, the pedagogical experiment aimed at testing the professional readiness for combat flights of future tactical aviation pilots is designed to assess the following components: cognitive, operational, motivational and volitional, and physical. Each of these components is assessed using its own set of methods.

Discussion

In general, the category of "quantity" in pedagogical research is borrowed from mathematics and still does not have a unanimous understanding. It is used to denote several definitions in relation to pedagogical objects (phenomena, processes, systems): the strength of a certain set; quality in the spatial and temporal aspect; the relation of parts to the whole or a separate

part; and elements of the whole. As Tsiura (2013) rightly notes in this regard, "'quality' and 'quantity' reflect the objective aspects and relations of objects ..., any quality is expressed in a system of quantitative characteristics specific to it." However, this does not prevent the active use of the concept of "quantity" in the context of interdisciplinary measurement theory in modern pedagogical research. Therefore, the need for an objective assessment of the pedagogical phenomena under study naturally requires using both a qualitative approach (substantive elements of the study) and a quantitative approach (formalized elements of the study), which is the methodological basis for the test in our experiment. This research design is entirely consistent with the general methodological position accepted in modern scientific theory, according to which any new research of phenomena, processes, and facts of reality, including pedagogical, should consist of two basic methodological blocks theoretical (the level of specific scientific methodology) and experimental (the level of methodological techniques of cognition) (Lavrychenko, 2018).

Since today in science, it is considered a priori that the most accurate form of measurement and diagnosis of research objects is their quantitative assessment (quantitative description of the quality of the subject of knowledge), we are talking here about the use of qualimetric (from Latin "qualis" – quality and ancient Greek "metro" – to measure) approach (Honcharenko, 1997). Furthermore, in the modern Eastern European scientific direction of qualimetrics, a separate section is developing - pedagogical qualimetrics, the essence of which is the application of qualimetric methods to the assessment of psychological, pedagogical, and didactic objects. In turn, the core of the quantitative methodology of qualimetrics is the theory of measurement, which is based on scaling at this stage of its development.

Within the latter, there are five types of measurement scales: the scale of names, the scale of order, scale of intervals, the scale of relations and the scale of differences (Dawis, 1992). The key characteristics and requirements for any scale are reliability (the amount of inevitable measurement error and the possibility of repeating the measurement with the same result) and validity (the suitability of the scale for measuring a particular property).

Based on the above, the process of quantitative measurement of pedagogical phenomena, according to Rosenberg & Koehler (2015), looks in general as follows: identification and qualitative description of the subject of measurement (characteristics, attributes, etc.) → compilation and/or selection of measures (criteria, tests, etc.) → scaling (construction of scales to which the measures correspond) → determination of primary ("raw") empirical measurement data obtained in the course of a pedagogical experiment → mathematical and statistical processing of primary data → meaningful interpretation of the results of measurement and processing. Therefore, to diagnose the components of professional readiness for combat flights of future tactical aviation pilots, it is most appropriate in the procedural aspect to select theoretically and empirically tested qualimetric methodology(-s) based on a specific measurement scale with a highly proven level of reliability and validity.

The results should be used in the future to improve the training process of military pilots as follows:

- For the performance any pedagogical experiments based on the recommendations for designing a pedagogical experiment;

- To verify the pedagogical system efficiency of ensuring the quality of professional training for combat flights of future tactical aviation pilots;
- To identify individuals with an unsatisfactory level of development of a particular component of professional training who need additional individual training.

It is important to emphasize that this study concerned only the scientific and methodological principles of organizing and implementing a pedagogical experiment to test the effectiveness of the pedagogical system of ensuring the quality of professional training for combat flights of future tactical aviation pilots, is generalized and will be further supplemented by studies of the results of testing each component (table 1). Such a study will give the best result and help substantiate the effectiveness of the pedagogical system in the context of each component of professional training.

Conclusions

Based on the results of the study, the following conclusions can be drawn regarding the proposed scientific and methodological approach to organizing a pedagogical experiment aimed at testing the pedagogical system's efficiency in ensuring the quality of professional training for combat flights of future tactical aviation pilots. Firstly, it is substantiated that a pedagogical experiment is the most appropriate basis for this scientific and methodological approach. Secondly, it is proposed to test the efficiency of the pedagogical system by conducting a formative, natural (based on performance conditions), partially modeled (by the type of interaction between the object and the means of study), real (based on the type of the object under study), and multifactor experiment.

The pedagogical experiment consists of three stages: the first, formative and ascertaining stage; the second, organizational and pedagogical stage; and the third, ascertaining and formative stage. At these stages, the author's approaches, activities, and innovations introduced into the professional training system of future tactical aviation pilots are quantitatively tested and evaluated to improve their quality. The experiment first identifies the insufficient level of specific competencies and then conducts a formative experiment to improve these levels.

It is recommended to assess each component of professional readiness for combat flights of future tactical aviation pilots separately, namely the cognitive, operational, motivational, and volitional, as well as physical components. Each of these components is assessed using its own set of methods: the cognitive component is assessed using a comprehensive R. Amthauer Intelligence Structure Test; the operational component is assessed by detecting a simulated failure (in seconds) and the cadet's actions in case of a failure (in seconds); the motivational and volitional components are assessed by conducting diagnostics using the K. Zamfir method (as modified by A. A. Rean) according to the diagnostic method of N. Ye. Stambulova; and the physical component is assessed by applying a comprehensive physical test (according to the methods of R. M. Makarov) and by using the diagnostics of self-assessment of the functional state by the "SAN" method (according to V. A. Doskin et al.).

In summary, the scientific novelty of this study lies in the development and substantiation of a scientific and methodological approach to organizing a pedagogical experiment aimed at testing the pedagogical system's efficiency in ensuring the quality of professional training for

combat flights of future tactical aviation pilots.

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