Supplementary educational program of technical focus "Clever"

Age of children: 11 - 17 years

Period of implementation: 72 hours

Moscow city 2017

Introduction

In recent years, the popularity of small unmanned aerial vehicles (UAV) with remote control and multi-copters in particular has grew considerably. And if in the past the UAVs were perceived by most people only as high-tech toys, now the situation has changed. Many of these devices are used to perform serious tasks: photo- and videoshooting, aerial survey and monitoring of various objects, processes and phenomena, including the monitoring of inaccessible objects, photogrammetry, delivery of small cargoes, etc. Rapid introduction of multicopters into our daily lives requires users to possess up-to-date knowledge in the fields of UAV operation, programming, assembly and maintenance, which are needed to quickly develop a new industry.

The “Aero” area of education are interdisciplinary classes that integrate science, technology, engineering and mathematics. The study of UAVs allows students to familiarize themselves with the technologies of the 21st century, promotes the development of their communicative abilities, develops the skills of interaction, decision-making independence, reveals their creative potential. Children and adolescents absorb material much better when they create or invent something themselves.

The "Clever Drone" educational environment facilitates the chosen strategies of training and helps reinforce the through practice the general subject knowledge (physics, mathematics and computer science). New GEF demands study of the foundations of design and project activities, something the “Aero” program satisfies in the fullest.

Explanatory note

Supplementary education educational program "Clever Drone" has a scientific and technical orientation with elements of natural sciences. The program is designed for 72 academic hours and provides an array of technical and natural-science competences, which a contemporary school student can master, focused on scientific, technical and technological areas of further education and professional skills. Program is primarily aimed at schoolchildren who want to study the areas of unmanned aerial vehicles application and the design, piloting, calibration and programming practical skills for unmanned aerial vehicles. The educational program aims to familiarize students with the basics of physics and modern capabilities of unmanned aerial vehicles, by completing situational cases and tasks, as well as identification, development and support of talented students and individuals with exceptional abilities, who will become a reliable foundation for the development of unmanned aerial vehicle industry in the future.

Educational program "Clever" helps to get an understanding of non-trivial technologies through practice, allowing the student to then realize their own technical solutions, as in design, assemble, calibrate and program them.

The study of UAVs makes it possible to combine the design and programming in one course, helping to integrate study of technology, computer science, mathematics, physics, drawing, natural sciences with the cultivation of engineering thinking, through technical creativity.

The novelty of the program is in the technological approach to the use a constructor kit in the educational process, which allows the student to master the skills of design, calibration and operation of an unmanned aerial vehicle.

The goal of the program is the growth of competencies in the field of unmanned aerial systems, the development of creative, scientific and technical potential of students, via organization of project activities as part of the creation of one’s own unmanned aerial vehicle.

The main tasks of the educational program

- vocational guidance of schoolchildren;
- coaching of persons with unique competences, to facilitate the development of the unmanned aerial vehicles industry;
- induce students' interest in the scientific and technical spheres;
- development of students’ critical and analytical thinking;
- development of a creative attitude to the work;
- nurture the ability to work in a team, effectively distribute duties;
- development of the awareness of the technology’s role and for progressive development of the society;
- the formation of a wholesome understanding of the technosphere, the essence of technological and labor culture;

- understanding of social and environmental consequences of industrial and agricultural development; energetics and transportation, including unmanned transportation;
- development of creative initiative and independence;
- development of psycho-physiological qualities of pupils: memory, attention, the ability to think logically, analyze, focus on the main thing.
- development of the ability to comprehensively express thoughts, defend one's point of view, analyze the situation and independently find answers to questions by logical reasoning.

The program is aimed at children aged 11-17 years, with the implementation period of 72 hours. The two hour classes are held twice a week in the form of lectures and practical classes. In these classes students are taught theory, given practice tasks aimed at solving technical problems, cases are studied and composed.

In their work, students employ various teamwork techniques, to facilitate cooperation training, subjecting ones work to self-evaluation, a mutual assessment, ability to work with the technical literature and to allocate the main thing are used. Realizing the engineering research project, the students master the basics of radio electronics and electromagnetism, get the first ideas about the structure and functioning of the Copters, design and build their quadcopter and test the work with the possibility of further modification. As a result of the development of the educational program, participants are expected to participate in competitions dedicated to the management of unmanned aerial vehicles.

The practical results of studying the course "Robotics" is the formation of the following knowledge and skills:

Knowledges about:

- history and development tendencies of Unmanned Aerial Vehicles and how their characteristics can be improved;
- safety regulations for the operation of the UAV;
- main copter components;
- design features of different models, structures and mechanisms;
- computer environments for flight controller calibration;
- basics of flight aerodynamics;
- basics of electricity and electronics;
- basics of 3D modelling;
- application of machine vision;
- structural features of different UAVs and their application;
- methods of calibration and pre-flight maintenance.

Skills:

- apply methods of educational, research and design activity, creative task resolution, modeling, design and aesthetic styling of products, ensuring safety of labor products;
- model and design multicopter unmanned aerial vehicles;
- calibrate flight controllers of different manufacturers with specialized software;
- create missing components for project realization through 3D modelling and fabricate them on a 3D printer.

Educational plan

№	Modules	Number of hours			Contents
		Theory	Practice	Total	
1	UAV Theory	12	-	12	**Theory:** Course briefing. Covers future activities. Types of UAVs. History of UAVs. Types of copters. Primary basic elements of copters. Theory of UAV piloting. Copter of manual control. Flight controller. Engine controllers. Brushless motors. Air propeller theory. Batteries.
2	UAV Design	6	4	10	**Theory:** Copter calculation. Choice of motor and propeller. Weight, power availability, energy availability, flight time. Soldering theory. **Practice:** Work with systems of automatic engineering. Practical task of changing the copter's frame structure.
3	Assembly and calibration of copters	4	10	14	**Theory:** Accident prevention during soldering and working with Li- Po batteries. Safety in the assembly and adjustment of Copters, in preparation for launch. **Practice**: Checking the kit components, assembling the frame. Soldering regulators to motors and power board. Installing the elements on the

					frame. Installation of control equipment. Checking the rotation of the motors. Installing the flight controller. Flight controller setup. The final assembly of the elements of the Copter.
4	Line-of-sight piloting	8	16	24	**Theory**: Theory of manual line-of-sight piloting. Accident prevention during flight operation of Copters. Pilot procedures. Checklists. Repetition of accident prevention. Exam on safety prevention. Pass checklist for preparation. **Practice**: Flying on the copter. Hovering. Piloting in the flight area. Landing. Forward-backward, left-right movement. Flying in a circle, with back to the pilot. Hovering sideways in relation to the pilot. Flight back and forth and left-right sideways in relation to the pilot. Flying left to right sideways in relation to the pilot, with a turn Flying with the front facing the pilot. Forward-backward, left-right, facing the pilot. Reinforcing acquired skills at high altitude. Flight in a circle with the nose forward.
5	First-point-view piloting	4	8	12	**Theory**: FPV flights. Equipment for video transfer and OSD. Flight mission and FPV piloting theory. **Practice**: Workshop - preparation and adjustment of video equipment. Control exercises. Flight on the route. Installation of the course elements and flying through the course. Practical training.
	Total	34	38	72	

Program implementation requirements

Itinerary for the program includes:

1. Computers with special software installed.
2. Drone kits for “COEX Clever Drone” assembly.
3. A lab, equipped with soldering stations, exhausts and necessary tools.
4. Flight zone or permissions to fly outdoors.

Educational materials for the program include:

1. Informational resources on the website, dedicate to this supplementary educational program.
2. Assembly and calibration manuals
3. Methodical literature on the main modules of the program.

The teaching and educational process is aimed at developing the natural talents of children, for the realization of their interests and abilities. Each lesson focuses on the development of the child's personality. When planning and conducting classes, the person-oriented educational methodology is applied, which focuses on the individual, striving to realize their capabilities, as well as the activity theory of teaching. This program allows a creative, improvisational approach on the part of children and the teacher, in regards to the possible rearrangement of the order of material in the course, the introduction of additional material and methodologies for conducting classes.

Guided by this program, the teacher has the opportunity to increase or decrease the amount and degree of technical complexity of the material, depending on the composition of the group and the specific working conditions.

Types of classes:

- Lecture classes with elements of game activities for better understanding of the material and switching between activities.
- Practical exercises, including work on a project to create their own unmanned aerial vehicle and control the technological process. In practical classes, students receive the necessary skills for soldering, working with various equipment, and applying theoretical knowledge from such sciences as physics, chemistry, and mathematics.
- Trips to production facilities related to aircraft technology, which allow the student to form an idea of the industry development and its prospects.

- Competitions that can be held both as part of the educational process and external competitions of various levels, from regional to global.

Students on the first day of classes are instructed on safety rules in the classroom and in the unmanned aerial vehicles operation. The teacher at each session reminds the students about the basic rules of observance of safety precautions.

The main principles of education are:

1. Scientific. This principle ensures that the students are only taught reliable, practice-verified information, the selection of which takes into account the latest achievements of science and technology.

2. Accessibility. It matches the volume and depth of the educational material to the level of general development of students, thanks to which knowledge and skills can be consciously and firmly acquired.

3. Relationship between theory and practice. Obligates to conduct classes so that students can consciously apply the knowledge they have acquired in practice.

4. Disciplinary effects of study. The learning process is disciplinary, the learner not only acquires knowledge and develops skills, but also develops his abilities, mental and moral qualities.

5. Consciousness and activity of training. In the learning process, all the actions that the student undertakes must be justified. It is necessary to teach, learn, critically analyze, and evaluate the facts, draw conclusions, resolve all doubts so that the process of learning and working out the necessary skills will occur consciously, with full conviction in the correctness of the study. Eagerness in learning implies independence, which is achieved by good theoretical and practical training and the work of the teacher.

6. Clarity. Explanation of the flying robotics assembly techniques, tested on specific products and software. For clarity, existing video materials are used.

7. Systematic and consistent approach. The educational material is taught according to a specific system and in a logical sequence, to maximize comprehension. As a rule, this involves studying the subject from the basics to the more complex material, from the individual cases to general.

8. Quality of knowledge and skills learning. The quality of education depends on how firmly the knowledge, skills and abilities of students are firmly fixed. Difficult knowledge and skills are usually the cause of uncertainty and error. Therefore, the consolidation of skills and skills should be achieved by repeated targeted repetition and training.

Forms of summarizing module material:

1. UAV theory: In this module, the learners receive basic theoretical information about the history and development of unmanned aerial vehicles, and can form their own views on the industry and, as a result, can build theories on how to improve existing technologies and apply them in their own projects. In the course, each student's subject of interest is revealed and the learners are given the task of searching for information in industry literature and on the Internet. Also, to assess the quality of knowledge absorption, a theoretical survey is used in a form of a game, with explanations from the teacher.

2. UAV design: As part of the module summary process, the quality of design and 3D models created by the learners are assessed, with their strengths and weaknesses being noted, as well as the options for future modification.

3.UAV assembly and calibration: Evaluation of the finished projects' quality, with their strengths and weaknesses being noted, followed by the rectification of defects.

4. Line-of-sight piloting: a final competition between learners from a group, with the ability to move on to the next step step of the competition, or ven to external competitions.

5. First-person-view piloting (FPV): a final competition between learners from a group, with the ability to move on to the next step step of the competition, or ven to external competitions.

List of Literature

1. CopterExpress Clever [Digital resource]. - https://github.com/CopterExpress/clever

Supplementary educational program of technical focus "Clever"

Age of children: 11 - 17 years

Period of implementation: 144 hours

Moscow city 2017

Introduction

In recent years, the popularity of small unmanned aerial vehicles (UAV) with remote control and multi-copters in particular has grew considerably. And if in the past the UAVs were perceived by most people only as high-tech toys, now the situation has changed. Many of these devices are used to perform serious tasks: photo- and videoshooting, aerial survey and monitoring of various objects, processes and phenomena, including the monitoring of inaccessible objects, photogrammetry, delivery of small cargoes, etc. Rapid introduction of multicopters into our daily lives requires users to possess up-to-date knowledge in the fields of UAV operation, programming, assembly and maintenance, which are needed to quickly develop a new industry.

The “Aero” area of education are interdisciplinary classes that integrate science, technology, engineering and mathematics. The study of UAVs allows students to familiarize themselves with the technologies of the 21st century, promotes the development of their communicative abilities, develops the skills of interaction, decision-making independence, reveals their creative potential. Children and adolescents absorb material much better when they create or invent something themselves.

The "Clever Drone" educational environment facilitates the chosen strategies of training and helps reinforce the through practice the general subject knowledge (physics, mathematics and computer science). New GEF demands study of the foundations of design and project activities, something the “Aero” program satisfies in the fullest.

Explanatory note

Supplementary education educational program "Clever Drone" has a scientific and technical orientation with elements of natural sciences. The program is designed for 144 academic hours and provides an array of technical and natural-science competences, which a contemporary school student can master, focused on scientific, technical and technological areas of further education and professional skills. Program is primarily aimed at schoolchildren who want to study the areas of unmanned aerial vehicles application and the design, piloting, calibration and programming practical skills for unmanned aerial vehicles. The educational program aims to familiarize students with the basics of physics and modern capabilities of unmanned aerial vehicles, by completing situational cases and tasks, as well as identification, development and support of talented students and individuals with exceptional abilities, who will become a reliable foundation for the development of unmanned aerial vehicle industry in the future.

Educational program "Clever" helps to get an understanding of non-trivial technologies through practice, allowing the student to then realize their own technical solutions, as in design, assemble, calibrate and program them.

The study of UAVs makes it possible to combine the design and programming in one course, helping to integrate study of technology, computer science, mathematics, physics, drawing, natural sciences with the cultivation of engineering thinking, through technical creativity.

The novelty of the program is in the technological approach to the use a constructor kit in the educational process, which allows the student to master the skills of design, calibration and operation of an unmanned aerial vehicle.

The goal of the program is the growth of competencies in the field of unmanned aerial systems, the development of creative, scientific and technical potential of students, via organization of project activities as part of the creation of one’s own unmanned aerial vehicle.

The main tasks of the educational program

- vocational guidance of schoolchildren;
- coaching of persons with unique competences, to facilitate the development of the unmanned aerial vehicles industry;
- induce students' interest in the scientific and technical spheres;
- development of the students’ critical and analytical thinking;

- development of the awareness of the technology’s role for progressive development of the society;
- the formation of a wholesome understanding of the technosphere, the essence of technological and labor culture;
- understanding of social and environmental consequences of industrial and agricultural development; energetics and transportation, including unmanned transportation;

The program is aimed at children aged 11-17 years, with the implementation period of 144 hours. The 2-hour classes are held twice a week in the form of lectures and practical classes. In these classes students are taught theory, given practice tasks aimed at solving technical problems, cases are studied and composed.

In their work, students employ various teamwork techniques, to facilitate cooperation training, subjecting one’s work to self-evaluation, a mutual assessment, ability to work with the technical literature and to allocate the main thing are used. Realizing the engineering research project, the students master the basics of radio electronics and electromagnetism, get the first ideas about the structure and functioning of the Copters, design and build their quadcopter and test the work with the possibility of further modification. As a result of the development of the educational program, participants are expected to participate in competitions dedicated to the management of unmanned aerial vehicles.

The practical results of studying the course "Aero" is the formation of the following knowledge and skills:

Knowledges:

- history and development tendencies of Unmanned Aerial Vehicles and how their characteristics can be improved;
- safety regulations for the operation of the UAV;
- main copter components;
- design features of different models, structures and mechanisms;
- computer environments for flight controller calibration;
- basics of flight aerodynamics;
- basics of electricity and electronics;
- basics of 3D modelling;
- application of machine vision;
- structural features of different UAVs and their application;

- methods of calibration and pre-flight maintenance.

Skills:

- apply methods of educational, research and design activity, creative task resolution, modeling, design and aesthetic styling of products, ensuring safety of labor products;
- model and design multicopter unmanned aerial vehicles;
- calibrate flight controllers of different manufacturers with specialized software;
- create missing components for project realization through 3D modelling and fabricate them on a 3D printer;
- perform line-of-sight piloting of an unmanned aerial vehicle through the use of FPV equipment;
- create the missing elements necessary for completion of the projects, using 3D modelling software and printing them using 3D printing equipment;
- interface with the Raspberry microcomputer, know the basics of Linux administration;
- plan and write-up flight tasks and missions;
- program and perform autonomous flights; perform pre-flight maintenance.

Educational plan

№	Modules	Number of hours			Contents
		Theory	Practice	Total	
1	UAV Theory	17	-	17	**Theory:** Course briefing. Covers future activities. Types of UAVs. History of UAVs. Types of copters. Primary basic elements of copters. Theory of UAV piloting. Copter of manual control. Flight controller. Engine controllers. Brushless motors. Air propeller theory. Batteries.
2	UAV Design	4	6	10	**Theory:** Copter calculation. Choice of motor and propeller. Weight, power availability, energy availability, flight time.

					Soldering theory. **Practice:** Work with systems of automatic engineering. Practical task of changing the copter's frame structure. Creating a model for 3D printing with AutoCAD software
3	Assembly and calibration of copters	2	10	12	**Theory:** Accident prevention during soldering and working with Li- Po batteries. Safety in the assembly and adjustment of Copters, in preparation for launch. **Practice**: Checking the kit components, assembling the frame. Soldering regulators to motors and power board. Installing the elements on the frame. Installation of control equipment. Checking the rotation of the motors. Installing the flight controller. Flight controller setup. The final assembly of the elements of the Copter.
4	Line-of-sight piloting	5	11	16	**Theory**: Theory of manual line-of-sight piloting. Accident prevention during flight operation of Copters. Pilot procedures. Checklists. Repetition of accident prevention. Exam on safety prevention. Pass checklist for preparation. **Practice**: Flying on the copter. Hovering. Piloting in the flight area. Landing. Forward-backward, left-right movement. Flying in a circle, with back to the pilot. Hovering sideways in relation to the pilot. Flight back and forth and left-right sideways in relation to the pilot. Flying left to right sideways in relation to the pilot, with a turn Flying with the front facing the pilot.

					Forward-backward, left-right, facing the pilot. Reinforcing acquired skills at high altitude. Flight in a circle with the nose forward. Flight in in an eight-shaped trajectory, nose forward. Reinforcing acquired skills. Flights in unusual places.
5	Radioelectronics and Programming	10	7	17	**Theory:** Basics of radio electronics, circuitry and prototyping of electronic circuits. Analog and digital signals. Principles of work with laboratory measuring equipment. Basics microelectronics and microcontroller programming. Communication between the flight controller and an additional on-board microcontroller. Transmission of telemetry and control commands. **Practice:** Workshop “Basics of radio electronics, circuitry and prototyping of electronic circuits”. Workshop “Study of electric signals with laboratory equipment”. Workshop “Introduction to microcontroller programming”.
6	First-point-view piloting	6	19	25	**Theory**: FPV flights. Analogue and digital video transmission. The used cameras, radio transmitters and receivers. Equipment for video transfer and OSD. Flight mission and FPV piloting theory. **Practice**: Workshop - preparation and adjustment of video equipment. Control exercises. Flight on the route. Installation of the course elements and flying through the course. Practical training.
7	Autonomous unmanned aerial systems	17	30	47	**Theory:** The history of autonomous flights. Development of autopilots in aviation.

					Accident prevention during electrical installation. Basics of Python programming. Automatic control systems with feedback loop. PID regulators. Use of a barometric sensor to maintain altitude. Methods of obstacle collision prevention for UAVs. Methods for determining the distance to obstacles. Work principles of ultrasonic sonar and of working with it. Basics of computer vision. Construction of 3D-models with the help of specialized software. Using drones for photogrammetry. **Practice:** Introduction to the Raspberry Pi 3 computer. Workshop "Programming on-board computer". UAV flight tests with on-board computer. Workshop “PID controller”. UAV stabilization with a barometric sensor” UAV flight tests with an altitude stabilization system. UAV flight tests with a collision avoidance system. Workshop "Designing and programming a collision avoidance system using ultrasound sonars". Recognition of markers and application of computer vision on the UAV.
	Total	61	83	144	

Program implementation requirements

Itinerary for the program includes:

1. Computers with special software installed.
2. Drone kits for “COEX Clever Drone” assembly.

3. A lab, equipped with soldering stations, exhausts and necessary tools.

4. Flight zone or permissions to fly outdoors.

Educational materials for the program include:

1. Informational resources on the website, dedicate to this supplementary educational program.

2. Assembly and calibration manuals.

3. Methodical literature on the main modules of the program.

The teaching and educational process is aimed at developing the natural talents of children, for the realization of their interests and abilities. Each lesson focuses on the development of the child's personality. When planning and conducting classes, the person-oriented educational methodology is applied, which focuses on the individual, striving to realize their capabilities, as well as the activity theory of teaching. This program allows a creative, improvisational approach on the part of children and the teacher, in regards to the possible rearrangement of the order of material in the course, the introduction of additional material and methodologies for conducting classes.

Guided by this program, the teacher has the opportunity to increase or decrease the amount and degree of technical complexity of the material, depending on the composition of the group and the specific working conditions.

Types of classes:

- Lecture classes with elements of game activities for better understanding of the material and switching between activities.
- Practical exercises, including work on a project to create their own unmanned aerial vehicle and control the technological process. In practical classes, students receive the necessary skills for soldering, working with various equipment, and applying theoretical knowledge from such sciences as physics, chemistry, and mathematics.
- Trips to production facilities related to aircraft technology, which allow the student to form an idea of the industry development and its prospects.
- Competitions that can be held both as part of the educational process and external competitions of various levels, from regional to global.

Students on the first day of classes are instructed on safety rules in the classroom and in the unmanned aerial vehicles operation. The teacher at each session reminds the students about the basic rules of observance of safety precautions.

The main principles of education are:

1. Scientific. This principle ensures that the students are only taught reliable, practice-verified information, the selection of which takes into account the latest achievements of science and technology.

2. Accessibility. It matches the volume and depth of the educational material to the level of general development of students, thanks to which knowledge and skills can be consciously and firmly acquired.

3. Relationship between theory and practice. Obligates to conduct classes so that students can consciously apply the knowledge they have acquired in practice.

4. Disciplinary effects of study. The learning process is disciplinary, the learner not only acquires knowledge and develops skills, but also develops his abilities, mental and moral qualities.

5. Consciousness and activity of training. In the learning process, all the actions that the student undertakes must be justified. It is necessary to teach, learn, critically analyze, and evaluate the facts, draw conclusions, resolve all doubts so that the process of learning and working out the necessary skills will occur consciously, with full conviction in the correctness of the study. Eagerness in learning implies independence, which is achieved by good theoretical and practical training and the work of the teacher.

6. Clarity. Explanation of the flying robotics assembly techniques, tested on specific products and software. For clarity, existing video materials are used.

7. Systematic and consistent approach. The educational material is taught according to a specific system and in a logical sequence, to maximize comprehension. As a rule, this involves studying the subject from the basics to the more complex material, from the individual cases to general.

8. Quality of knowledge and skills learning. The quality of education depends on how firmly the knowledge, skills and abilities of students are firmly fixed. Difficult knowledge and skills are usually the cause of uncertainty and error. Therefore, the consolidation of skills and skills should be achieved by repeated targeted repetition and training.

Forms of summarizing module material:

1. UAV theory: In this module, the learners receive basic theoretical information about the history and development of unmanned aerial vehicles, and can form their own views on the industry and, as a result, can build theories on how to improve existing technologies and apply them in their own projects. In the course, each student's subject of interest is revealed and the learners are given the task of searching for information in industry literature and on the Internet. Also, to assess the quality of knowledge absorption, a theoretical survey is used in a form of a game, with explanations from the teacher.

2. UAV design: As part of the module summary process, the quality of design and 3D models created by the learners are assessed, with their strengths and weaknesses being noted, as well as the options for future modification.

3.UAV assembly and calibration: Evaluation of the finished projects' quality, with their strengths and weaknesses being noted, followed by the rectification of defects.

4. Line-of-sight piloting: a final competition between learners from a group, with the ability to move on to the next step step of the competition, or ven to external competitions.

5. Radioelectronics and programming: assessment of the acquired knowledge is performed by testing the learners on their knowledge of the basic vocabulary and problem solving

6. First-person-vision piloting: final competition between members of a group, with a possibility of moving to the next competition level or outside competitions.

7. Autonomous unmanned aerial systems: final competition, flying and autonomous drone through the marker field.

List of Literature

1. CopterExpress Clever [Digital resource]. -

https://github.com/CopterExpress/clever