UDC 004.584

[2]**Gumennykova Tamara,** Doctor of pedagogical sciences, professor, professor of the Department of the social sciences, E-mail: gumennikova100@gmail.com , ORCID: 0000-0002-6223-7711
[1]**Blazhko Oleksandr**, Candidate of Technical Sciences, Associate Professor, Associate Professor of the System Software Department, E-mail: blazhko@ieee.org , ORCID: 0000-0001-7413-275X, Odessa, Ukraine
[1]**Luhova Tetiana,** Candidate of Art Sciences, Associate Professor of the Information Activity and Media Communications Department, E-mail: lug2308@gmail.com, ORCID: 0000-0002-3573-9978
[1]**Troianovska Yuliia**, Senior Lecturer of the Information System Department, E-mail: troyanovskaja@gmail.com, ORCID: 0000-0002-6716-9391
[1]**Melnyk Serhii**, Candidate of Social Communication Sciences, Associate Professor, E-mail: miroschnick@ukr.net, ORCID: 0000-0003-3996-9970
[3]**Riashchenko Oksana**, Teacher of Informatics, E-mail: oksanaivanovna561@gmail.com,
ORCID: 0000-0002-9242-0752
[1]Odessa National Polytechnic University, Odessa, Ukraine
[2]Prydunai Branch of Private joint-stock company "Higher educational institution "Interregional Academy of Personnel Management"
[3]Secondary school No. 10, Izmail, Ukraine

GAMIFICATION FEATURES OF STREAM-EDUCATION COMPONENTS WITH EDUCATION ROBOTICS

Annotation. *The article discusses the growth of staffing requirements for modern manufacturing companies, taking into account the emergence of the term Industry 4.0, which includes components: Cyber-Physical Systems, Internet of Things, Smart Factory, Internet of Services, Smart Product, Machine-to-Machine, Big Data, Cloud. The importance of introducing robotic tools, such as the electronic platform with an Arduino microcontroller, to educational directions such as STEM (stands for: "Science", "Technology", "Engineering" and "Mathematics"), STEAM (adding "Arts") and STREAM (adding "Reading/Writing"), is noted. But today they do not take into account the way to strengthen motivational activity based on computer games, therefore the purpose of the article was to establish two-way communication between the computer game design process using a robotic system and Arduino microcontroller sensors for later solving the task of determining the gamification characteristics of a given sensor, as well as the task of determining robotic characteristics of a given stage of the computer game design process. To achieve this goal, a data analysis technique is proposed, which includes the following steps. The stage of analyzing the functions of fairy tales by Vladimir Propp (hereafter, metaphorization functions), which forms a table of functions as templates of text phrases for creating a computer game script that takes into account the Arduino microcontroller sensors. The stage of the analysis of computer game classes, which forms the table of classes of the market for the game and the table of classes of players' needs. It is assumed that the product sales market is closely related to the various disciplines of the school curriculum. The stage of analysis of the components of the Mechanics-Dynamics-Aesthetics within the MDA-model. The stage of analysis of the Arduino microcontroller sensors. The proposed methodology allowed creating a relational database including the following tables: a table describing 31 templates of text phrases to create a plot of computer game; table describing 15 classes of players' needs; table describing 10 classes of MDA-model; table of descriptions for 19 Arduino microcontroller sensors; a table of relations between 31 templates of text phrases, scenarios from the Vladimir Propp's morphological functions of fairy tales, and descriptions of 15 classes of players' needs and 10 classes of the MDA model; table of interconnections between the descriptions of the Arduino microcontroller sensors, classes of players' needs and classes of the MDA model. Testing of the proposed methodology took place during master classes with participation of I-III stages' students of secondary school No.10 (Izmail, Odessa region) in the process of creating five computer games using the Scratch software tool for managing graphic objects based on signals from the Arduino UNO microcontroller sensors. In the future, it is proposed to consider interactive models of the design of robotic computer games that can be used in the described method, providing graphic means of displaying the components of the structural model of the method. As a result, this will require the development of a software integration module for the contents of the developed relational database and the internal structures of the software tools supporting these interactive design models.*

Keywords: *STREAM-education; education robotics; Arduino, computer game*

Introduction

Formulation of the problem

In the current decade, the term "Industry 4.0" is being actively discussed as a variant of the fourth industrial revolution in the form of a new round of automation and data exchange through the use of such components as: Cyber-Physical Systems, Internet of Things, Smart Factory, Internet of Services, Smart Product, Machine-to-Machine, Big Data, Cloud [1].

Production companies, in order to ensure future competitiveness, begin to create a development plan in the form of a technological roadmap [2], in which an important section is personnel with the necessary skills [3].

Industry 4.0, in turn, requires a new quality of staffing, creating a new educational format, Education 4.0, in the form of a system of continuous technical education, including levels of general, secondary vocational, higher and additional professional education [4].

In 2017, the World Economic Forum's Report "New Vision for Education: Fostering social and emotional learning through technology" offered the following skills as a result of Education 4.0 [5]: six basic types of literacy (Literacy, Numeracy, ICT literacy, Scientific literacy, Financial literacy, Cultural and Civic literacy); four competencies with which students approach solving complex challenges (Critical thinking, Creativity, communication, Collaboration); six qualities of character, using which pupils meet their changing environment (Curiosity, Initiative, Persistence/grit, Adaptability, Leadership and Social and cultural awareness).

Modern approaches to the study of the competence of graduates of schools, as future citizens of society working in Industry 4.0, are determined by the requirements of time by themselves. It is not enough in contemporary reality to have knowledge and skills in individual disciplines, but it is necessary to be able to combine them in a creative, innovative way to solve any task. Therefore, for many years pedagogical science has been looking for ways to attract the interest of preschoolers and schoolchildren to the learning process in the modern conditions of transition from post-industrial to informational society, especially considering the unexpected appearance of its intermediate stage in the form of Industry 4.0. The World Economic Forum Report, of course, did not describe new directions, but summarized the accumulated pedagogical experience of experimentally introducing robotic tools into educational processes in the form of design kits: from the educational robot Lego Mindstorms [6; 7; 8] to the electronic platform with the Andruino microcontroller [9; 10; 11]. In order to attract schoolchildren to the study of such tools, researchers and teachers began to introduce them into the optional STEM educational direction which stands for: Science, Technology, Engineering and Mathematics [21], developing recommendations [12; 13] and textbooks [16]. But numerous experiments have shown the need to engage the emotional intelligence of schoolchildren and to the natural, technical disciplines have been added creative and artistic disciplines as "A" letter, meaning "Arts", forming the educational direction STEAM [22]. For example, for the Arduino platform, software libraries of communication with the visual programming language Scratch, which is popular in computer science lessons, were intensively developed. They actively use images to visualize and animate the virtual world [14; 15; 17].

Since in Industry 4.0, the efficiency of man-machine interaction depends on the skills of communication between people [5], the letter R - Reading / Writing was added to STEAM, which should be understood as "writing and understanding the meaning of the text", creating a new educational direction STREAM [23; 24]. It is known that one of the most important forms of attracting children to any process of educational activity is gamification, which has been actively used in the management of business processes [25; 26], as well as learning processes [27], offering new results competencies Deeper Learning: Critical Thinking, Active Learning, Flipped Learning and Learning from Failure [28].

For its part, the Deeper Learning format actively uses project-based learning, involving children in solving technical problems [29], what makes it posiible to use 36 principles of instruction in the format of video games [30]. The effect of the gamification launch grows in the disciplines that create communication skills [31; 69]. In project training, a game can move from the form of an instrument to achieve a goal to the form of the goal itself, offering to solve gamification problems through the standard computer game development process (Game Design/Development) [32]. On the other hand, in the current decade, new ways of player interaction with the virtual world based on the Natural User Interface (NUI) appeared, for example, through MS Kinect human motion control sensors, Leap Motion, as well as augmented reality web cameras for desktop computers and smartphones [33]. It is these methods that are also key in the components of Industry 4.0.

In the works of Educational Robotics direction [6-17], the automatic control of robots by itself is already considered by the authors as a game process, without taking into account the theory and practice of gamification of the process in which the robot performs certain actions. In [18], the complexity of studying the mathematical and physical fundamentals of robotics without the involvement of schoolchildren in the gameplay is noted, and recommendations are given on gamification using the example of several games. In [19], the Edutronics game project is presented that allows children to become familiar with electronics and the Arduino platform based on a series of game scenarios. In [20], an analysis of computer games methods and characteristics of intelligent robots is presented, on the basis of which the concept of an intelligent robot that can be used in computer games is proposed, and methods for designing and implementing this robot were given. Unfortunately, these works only partially consider the theory of designing computer games with regard to their multicriteria classification.

This indicates the relevance of research in the direction of integrating the development of computer games based on robotic systems into the components of STREAM-education to support the educational process in Industry 4.0.

Related work

Considering the importance of the competences with which students approach to solving complex tasks, and the qualities of character, using which students meet their environment's changes presented in the World Economic Forum Report [5], it is necessary to consider the peculiarities of creating a computer game plot. Many games have long become a kind of interpersonal computer communication [56]. In this regard, communication messages that are used in marketing communications are often used in the design of computer games, for example, an archetypical appeal to power and domination. Using archetypal communicative messages, problems are replaced by a simplified view of the eternal struggle of pair of mythologized communities, us (friends) and them (aliens, foes), Black and White, East and West, etc. The attitude to these groups is based on the dichotomy "us and them": "we" are "good guys", "they" are "bad" ones.. Therefore, such communication becomes a myth-communication [57]. In such communication, carried out through myths, the process of coding personal meanings into messages can be represented as myth making. The personal meaning of the communicator becomes the universal meaning (experience) of the collective, or that which becomes the personal experience of everyone to whom it is addressed, by being transformed into an archetype.

Any computer strategy game will certainly contain an explicit or hidden narrative (a certain story) that cannot be built without metaphorization [58]. This circumstance allows us to represent all the genre diversity of computer games of this kind as a construct, which is built from repetitive blocks - the actions and attitudes of the characters of computer games. In this regard, we coundn't help drawing an analogy with the classification of the functions of fairy-tale heroes, which philologist and folklorist Vladimir Propp laid out in his fundamental, study "Morphology of the Folk Tale". In his scientific work, the Soviet scientist proceeded from the observation that the most diverse fairy-tale characters in different fairy tales act in the same way. Attributes of fairy tale characters change, the actions changes, i.e. the act of the hero (according to Propp is a way of performing functions). Propp discovered a pattern that identical functions are found in various fairy tales. As an example, he cited seven categories of actors: 1) villains; 2) dispatchers (those who call for help); 3 and 4) agents of activities or heroes and bogus heroes; 5) donors; 6) assistants; 7) the desired characters (princess or other prized persons). Studying the structure of the fairy tale, Vladimir Propp identified 31 functions [59]. These functions can be used when classifying ways to design computer games at the stage of determining the scenario of character behavior.

In Industry 4.0, the work of individual components should strive for maximum autonomy in relation to human activity. The same autonomy can have a gaming system. In [34] it is noted that the gaming system is a system of rules that limit the actions of players when they participate in an artificial conflict with each other, which is accompanied by emotions due to the ratio of the level of effort and ability of the players and forms the player's experience as a psychological need to repeat the game. It is this need for repetition that determines the possible autonomy of the gaming system in relation to its developers and, as a result, good marketing opportunities.

Although the process of developing most games begins with defining the scenario of game characters interaction as a literary work, in recent decades this process has ceased to be only art when the structural model MDA (Mechanics, Dynamics and Aesthetics) [35] became the methodological basis for this process.

These three words have been used informally for many years to describe various aspects of games, but the MDA structure provides precise definitions of these terms and tries to explain how they relate to each other and affect the player's experience. The MDA structure clarifies the terms "gameplay" and "fun" and uses their definitions to demonstrate the stimulating and discouraging properties of different dynamics for different types of aesthetic use of the game.

In the context of learning to create developing games, the structural model DPE (Design, Play and Experience) [36] was added to the MDA model, which shows not only the algorithm for creating a video game, but also the behavior of the game system as a teacher, its learning influence on the student-player. On the basis of the combination of these models, [37] considered the gamification of the process of mastering the fundamentals of economic mathematics by children of pre-school age based on the activation of their implicit knowledge (intuition, insight, guesswork), which resulted in the "Chocolate Mathematics" game for Android devices.

When automating individual stages of computer game development based on the MDA model used in gamification of production or training processes, it is important to structure the player's behavior as a game consumer in detail. Such structuring can be based on a multicriteria classification of computer games [63; 64], taking into account the following categories:

– concept-oriented category;

– project-oriented category;

– design-oriented category.

The concept-oriented category includes subclasses:

– by Purpose: divides the games according to the goals that they pursue when interacting with the player, for example, teach, convey a message, tell a story [64];

– taking into account the Market: divides the games by industry, for example, entertainment, education, health [63];

– taking into account the individual goals of the player [67], associated with the theory of motivation, for example, based on the work of Abraham Maslow “A theory of human motivation” [65].

The project-oriented category includes subclasses with regard to: the type of the game plot, the game mechanics component (GamePlay), player visualization tools, the number of players, the means for transmitting progress between players, the interface for receiving game information. The design-oriented category includes subclasses with consideration of the game launching platform; human-computer interaction (HCI-Human-Computer-Interface), programming method in the game development process.

Speaking of project training of students, in which they must skillfully use various tools to achieve the goal of creating a prototype of a useful product, it is necessary to consider a student in his interconnections with a computer game not as a passive consumer, but as its own creator, shaping the important skills of project roles presented in Fig. 1.

Even by the names of the them, it is possible to determine the interrelation of the design roles of the computer game development process with the components of STREAM education [45]: Science, Technology, Reading / Writing, Engineering, Arts, Mathematics.

At the same time, STREAM-research focuses mainly on a standard set of school subjects, based on various technological processes in the field of ecology, chemistry, and physics. But these studies do not pay attention to such a consumer product as a computer game, which is often associated with the very negative attitude of teachers towards such a consumer product, where the student becomes a passive consumer.

For the discipline, “Informatics” the key project role is the programmer. Over the past decade, visual block-oriented programming methods have emerged, applying which to create programs, the user only needs to move graphic blocks without typing texts except for creating variables and entering constant values [40].

It is known that block visual programming frees the user from monitoring the correctness of the syntax of the program, being a great help at the programming learning stage for schoolchildren. The most famous examples of programming environments are Scratch [41] and Blockly [42].

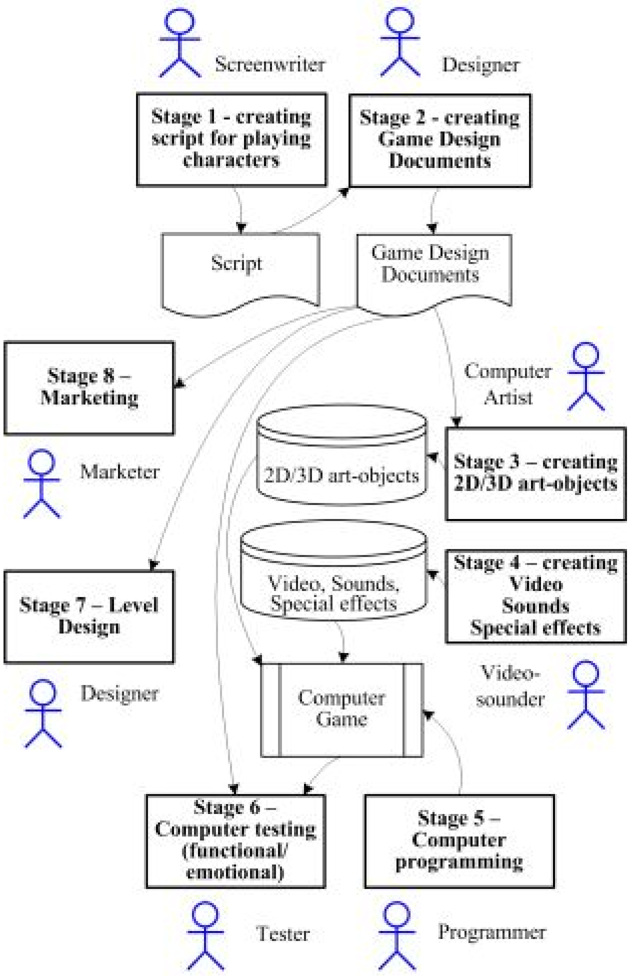

Fig. 1. Stages of the computer game design process, project roles and their results

In Industry 4.0, an important component is Augmented Reality technology using mobile devices based on smartphones running Android or iOS.

For the development of Android applications, the MIT App Inventor tool environment has been created using the Blockly visual editor [43]. All of these software environments are event-oriented, allowing you to implement multi-threaded algorithms for controlling the characters of a computer game. In the spring of 2019, the developers of MIT App Inventor plan to create a program code generator under iOS for Apple-based smartphones, which will allow creating cross-platform programs. In this case, students with a small level of knowledge in programming will be able to create programs whose functionality can compete with the functionality of programs developed by industrial software platforms of

C ++ / Java / C # languages, for example, with the Xamarin.Forms software platform [66].

Based on the Scratch programming environment, two extensions have been created for programming the Arduino microcontroller: mBlock for Arduino [60], Scratch for Arduino [61].

Algorithmic programming languages are not professional, but they allow you to quickly create a so-called prototype of the game, drawing the attention of the student to the algorithms and logic of the game, syntactic and technological subtleties [42]. At the same time, for more than 30 years, there has been a paradigm of automaton programming or "state programming" for developing programs based on finite automaton [38]. The advantages of the graphical representation of the program behavior in the form of a state machine model over algorithmic programming are the simplification of the analysis of the generated program code and the automation of testing. In modern instrumental development environments of games, for example, Unity 3D, there are many possibilities for using automated programming [51], but they are rather complicated for schoolchildren.

A few years ago, an experimental software environment MetaVerse [49] was created, which allows you to create iOS applications and Android applications under simplified scenarios based on automaton programming, thereby it became popular in US schools. One of the functional blocks of this environment contains software technology of augmented reality, which can also be used in the process of teaching schoolchildren in the format of Education 4.0

In the current decade, new ways of user interaction with the virtual world of a computer based on the natural interface have appeared, for example, through MS Kinect, Leap Motion sensor control technologies, as well as augmented reality web cameras for desktops and smartphones. All these technologies can be considered as a type of augmented reality for Industry 4.0 [33]. When programming human-machine interaction introduced into the components of Industry 4.0, technologies are used that take into account the features of game scenarios:

– virtually augmented reality through the camera of smartphones;

– actually augmented virtuality through sensors of control of human movements on the example of devices like Leap Motion and MS Kinect.

One example of the NUI-type interface is the use of the MS Kinect non-contact touch gaming controller for tracking human movement based on a set of a color camera, an infrared emitter and its depth sensor [46]. Such a controller can also be used for robotic programs. For example, in [62] it is used for indoor navigation based on the Google Robotic Operating System (ROS). The authors conducted a series of experiments to verify the quality of the Kinect sensor operation on an autonomous ground vehicle.

At first, to create games based on the controller, programming languages C# / C++ with a high level of knowledge about learning the programming process and assembling were offered, which are irresistible for most students. But the creation of the Kinect2Scratch software library by Microsoft's Stephen Howell volunteer significantly reduced this barrier [44]. When using the ScratchX web tool environment [17], we can combine the capabilities of MS Kinect and many other sensors whose JavaScript drivers are designed for this environment.

To conduct experiments on gamification of robotic systems, examples of developed games are needed. For example, in [55], a method was proposed for creating a truly augmented virtuality of training exercises with a ball based on the MS Kinect motion sensor controller, taking into account the large number of experiments for each physical exercise [50], according to which two master classes were organized in an initiative format "Meet and Code" within the weeks of the EU Code with the support of the Institute of Computer Systems (ICS) of the Odessa National Polytechnic University (ONPU) during the implementation of the ERASMUS + K2 project "GAMEHUB: University-enterprises cooperation in game industry in Ukraine" [52; 53]. Also in [55], existing games were analyzed, which are offered by software manufacturers in the world: LumoPlay [47], MotionMagix [48].

Analysis of 187 games of the LumoPlay software system determined the following distribution by classes: logical – 4 %, sports – 5 %, entertaining in various game genres – 30 %, relaxing with special effects – 61 %. And the analysis of 84 games of the MotionMagix software system determined the following distribution by class: logical – 14 %, sports – 15 %, entertainment in various game genres – 19 %, relaxing with special effects – 52 %. The 25 variants of games selected in the work can be the basis for conducting experiments on gamification of robotic systems, if we propose an alternative replacement for aesthetics, dynamics, and mechanics for a variety of Arduino microcontroller sensors.

Purpose of the research

The purpose of this article was to establish two-way communication between the process of designing a computer game using a robot system and Arduino microcontroller sensors for the subsequent solution of such problems:

– direct task – determination of gamificatio characteristics of a given sensor;

– inverse problem – determination of the robotic characteristics of a given stage of the computer game design process.

Research methods

The paper uses methods for analyzing computer game design processes, analyzing the characteristics of Arduino microcontroller sensors, methods for classifying games, and methods for abstracting games.

Presentation of the main research material

To establish two-way communication between the process of designing a computer game using a robotic system, and the Arduino microcontroller sensors, an appropriate data conversion method is proposed, presented in Fig. 2. with next stages.

Stage 1. Analysis of the functions of fairy tales by V. Ya. Proppu (hereinafter, the metaphorization function), which forms a table of functions as text phrase phrases to create a computer game script, taking into account the Arduino microcontroller sensors. This process is fundamental for the formation of STREAM component – Arts, supporting a creative approach to finding solutions to problems and using the possibilities of art when creating products for the user.

Stage 2. Analysis of computer games classes forms a table of game market classes and a table of player needs classes. The market for the product is closely related to the various disciplines of the school curriculum. This process supports the formation of STREAM component – Engineering, accompanying the process of creating prototypes of material products for consumers.

Stage 3. Analysis of the components of the Mechanics-Dynamics-Aesthetics MDA-model. This process supports the formation of STREAM-component - Mathematics, ensuring the formalization of the creative processes of designing computer games.

Stage 4. Analysis of the Arduino microcontroller sensors. This process supports the formation of the STREAM-component – Technology, providing skills in the use of software and hardware technologies to simplify the procedure for performing manual operations.

Stage 5. Analysis of all the structures prepared at the previous stages for the formation of relations between them. In this connection are formed separately between:

– metaphoring functions and game design components of a computer game;

– components of game design of a computer game and Arduino microcontroller sensors.

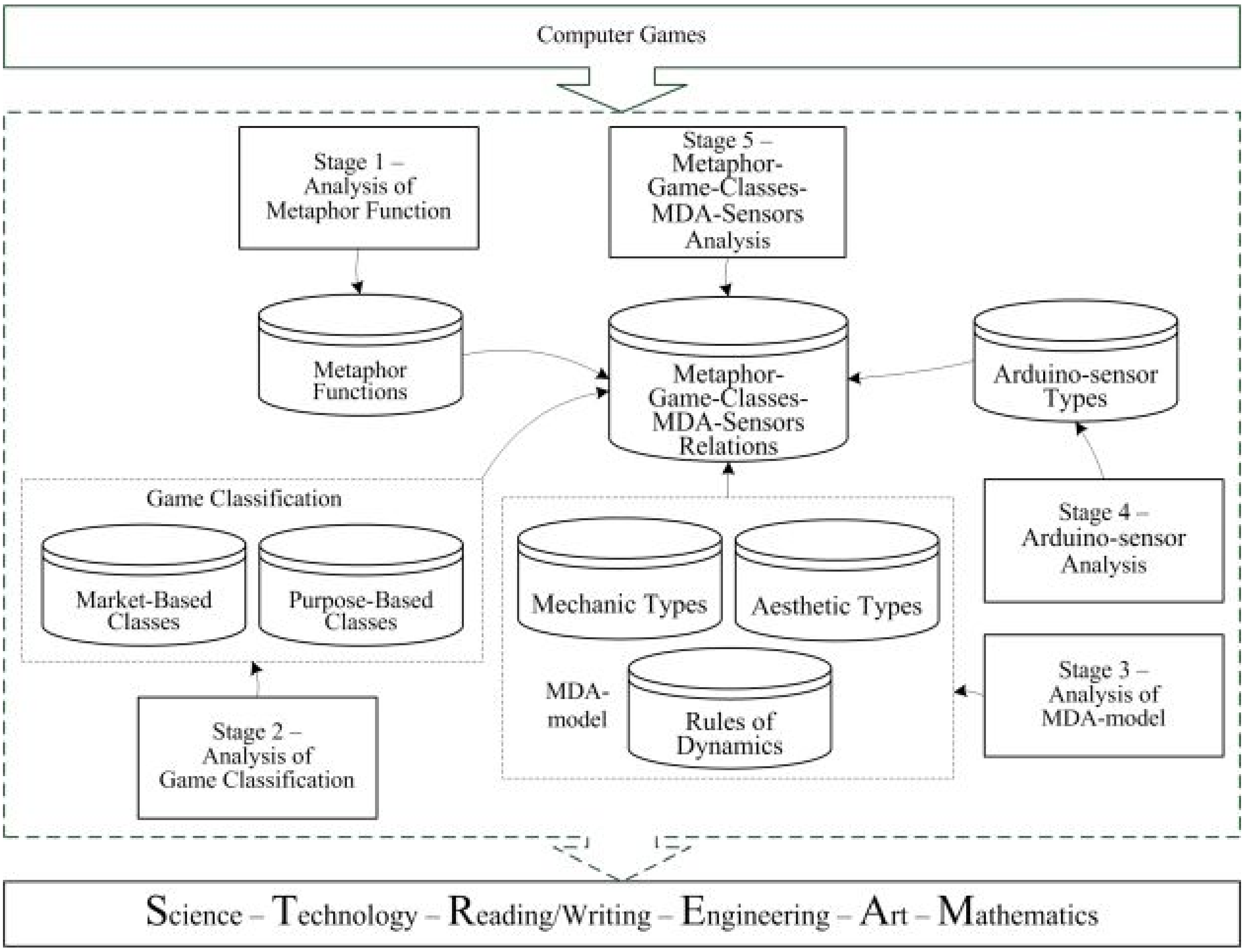

Fig. 2. Informational links between data structures and data transformation techniques

All presented analysis steps are performed in manual mode. But in order to reduce the laboriousness of performing the stages, it is further planned to introduce information technology of intellectual analysis following the example of work [70].

To establish two-way communication between the computer game design process using a robotic system and Arduino microcontroller sensors, it is proposed to formalize the design data structures used in the design process in the form of a structural model represented by the form:

$$< MF, MC, PC, MT, AT, DT, R^{(prop)}, R^{(sensor)} >,$$

where

$MF = \{mf_i\}, i \geq 1$ – the set of metaphorization functions according to Vladimir Propp;

$MC = \{mc_j\}, j \geq 1$ – the set of classes of games based on the market;

$PC = \{pc_l\}, l \geq 1$ – the set of classes of games based on the needs of the player;

$MT = \{mt_k\}, k \geq 1$ – the set of types of the "Mechanics" component from the MDA model;

$AT = \{at_r\}, r \geq 1$ – the set of types of the "Aesthetics" component from the MDA model;

$DT = \{dt_e\}, e \geq 1$ – the set of rules of the "Dynamics" component from the MDA model;

$ST = \{st_o\}, o \geq 1$ – the number of descriptions of the Arduino microcontroller sensors;

$R^{(prop)} = F(PC, MT, AT)$ – is the set of links between the sets of *PC*, *MT*, *AT* as a result of executing the function of mutual mapping of their elements onto each other;

$R^{(sensor)} = F(MF, ST)$ – is the set of links between the sets of *MF*, *ST* as a result of executing the function of mutual mapping of their elements onto each other.

The set of metaphorization functions *MF* contains elements represented by the form:

< action, function, example >

where *action* – basic definition of the action;
function – clarifying function;
example – example of a phrase from a script.

Many *PC*-based game classes based on player needs contains elements represented by the form:

<type, name, description>,

where
type – {information, action, control} – the type of need as the need for information, action and control;
name – class name;
description – class description.

The set of *MT* types of the "Mechanics" component contains elements represented by the form:

<type, name, description, example>,

where *type – {game, play}* – type of mechanics rule;
name – name of the rule;
description – description of the rule;
example – example of use in computer games.

The set of *AT* types of components "Aesthetics" contains elements represented by a deuce of the form:

<name, description>,

where *name* – name of the type of aesthetics;
description – description of the type of aesthetics.

The set of *ST* descriptions of the Arduino microcontroller sensors contains elements represented by the form:

<name, description>,

Where *name* – name of the sensor;
description – description of the features of the sensor.

All structural models were transformed into relational tables, examples of which are listed below.

As a result of data conversion processes are formed for the existence of conditions component *STREAM*-education [21-24; 55] shown in Table 1.

During creating a relational table of Metaphor Functions, an analysis of 31 functions by V. Ya. Propp was carried out [59]. The functions presented in Table 2 were selected to the database.

Table 1. Components *STREAM*-education supported the proposed method

STREAM-component	Description of skills
Science	Critical attitude to unverified facts
	Conducting research on the search for patterns and analysis of the results of experiments
Technology	Skills in using software and hardware technologies to simplify the procedure for performing manual operations
	Ability to reduce quantities of error procedures for executingmanual operations
Reading / Writing	The ability to convey the results of the work
	Ability to get the results of the work
Engineering	Creation for consumers prototype material products
Art	Creative approach to finding solutions to problems
	The use possibilities of art to create products for the consumer
Mathematics	Formalization of creative processes
	Using mathematical laws in solving problem

Table 2. Metaphorization functions (actions performed by the protagonist) with their possible use in the plot of robotic games (according to V. Ya. Propp)

MF	Basic definition of action	Clarifying function	Example phrases from scenario
1	Absence	One family member leaves home	Merchant leaves once for foreign countries
2	Ban	Hero is banned	Do not pick apples
3	Violation of ban	Ban is broken	Princess goes to the garden, they are late home
4	Leading out	Antagonist is trying to make intelligence	Tell me, Ivan is a merchant's son, where is your wisdom?
5	Issuance of	Antagonist given information about his victim	Koschey gives away the secret of his death
6	The catch	Antagonist tries to trick his victim to take her or her property	Stepmother gives stepson poisoned cakes
7	Involuntary aiding	Victim gives in fraud and the fact unwittingly helps the villain	The Hero no lulls, he suddenly he falls asleep, an enemy to facilitate his work
8	Harming	Antagonist causes one of the family members harm or damage	Snake kidnaps the daughter of the king
9	Shortage	One of the members of the family something was missing, it would be desirable to have Thu	Hero is single and goes to look for a bride
10	Mediation	Trouble or shortage reported to the hero to make requests or orders, send, or let his	Mother tells the son of the kidnapped daughter, happened to his birth
11	Start counter	Seeker agrees to, or decides to counter	Let us your princesses to find
12	Sending	Hero leaves home	Ivan Tsarevich took a blessing from his parent, chose a horse for himself, and went on a journey
13	Test	Hero is being tried, asked, attacked, etc., what is preparing to receive a magic tool or helper for	Three years to serve the merchant
14	Reaction to a test	Hero reacts to the actions of a future donor	Heroes secretly change clothes with their daughters of a yaga, she kills them instead of heroes
15	Getting a magic tool	At the disposal of the hero gets a magic tool	Old man gives a horse
16	Spatial displacement	Hero transferred, delivered, or searched object is to find a place	On horseback or on wolf
17	Fighting	Hero and his antagonist come into direct boron boo	Boy with kite or Chudo-Yudo
18	Branding	Hero of the mark as a result of previous actions	Princess marks hero ring
19	Victory	Antagonist vanquished	Snake killing a sleeping
20	Liquidation of trouble	Initial trouble or lack is liquidated	Harvest egg death Koshchey
21	Pursuit	Hero persecuted	Geese fly over girl
22	Rescue	Hero is rescued from pursuit	River, apple, girl in the oven are hidden
23	Hidden arrival	Hero not recognized arrives home or in another country	The hero arrives at a different king, enters the kitchen or serves
24	Unfounded claims	False hero makes unfounded claims	Brothers posing as earners, general – for the winner snake
25	Preparation difficult task	Hero serves difficult task	Ships living water
26	Difficult solution of the problem	The problem is solved	The hero manages to get living water
27	Recognition	Hero learn	Under unexpected circumstances, the hero is revealed and everyone recognizes him

Table 2 – continuation

MF	Basic definition of action	Clarifying function	Example phrases from scenario
28	Exposure	False hero or antagonist, the pest is exposed	Here the princess told everything as it was: all events are told from the very beginning in the form of a fairy tale. The pest is among the hearers; he gives himself away by cries of disapproval
29	Appearance issue	Hero is given a new look	With the hero, transfiguration takes place. It is dipped in water or allow to wear a magic item, so it takes a new look
30	Penalties	The enemy is punished	Enemy make fair harsh sentence beheaded or hounded out of the realm of
31	Wedding	Hero marries and reigns	"Then they got married and the sunset feast for the whole world"

As can be seen from the above table, each function (character's action) is a small structural element that can be stacked one on another, creating a kind of narrative (plot) that will be schematically constructed from three main positions:

– beginning – where they represent the charac ters;
– middle – a problem is formed or its resolution occurs;
– the end – the glorification of the hero.

When creating the Market Base Game database, classes from [63] were considered, taking into account the sales market. The selected classes are presented in Table 3.

Table 3. Examples of filling in the database of the Market Base Game

No.	Class of the game with regard to the sales market
1	Entertainment
2	State & Governement
3	Military & Defence
4	Healthcare
5	Education
6	Corporate
7	Religious
8	Culture & Art
9	Ecology
10	Politics
11	Humanitarian & Caritative
12	Media
13	Advertising
14	Scientific Research

When creating the Purpose-Base Game Classification database, A. H. Maslow pyramid was taken into account [65]. Assume that the consumer starts to play games to meet their needs of the upper levels of Maslow's pyramid:

– affiliation (chat, friendship, love);
– the recognition of (respect for others, self-esteem);
– Expressions (improvement, staff development ny).

Then we can consider the classification of games based on the criterion of the consumer's goal during the game and divide the games into three subclasses to meet the player's need for:

– information;
– action;
– control.

The player's need for information can be divided into the needs presented in Table 4.

Table 4. A description of the need to obtain Information

No.	Requirement	Description
I1	Education	For example, for preschoolers, this is the study of numbers, the alphabet, the names of things, and in a general sense, this is the study of terminology in any subject area
I2	Solving puzzles	As a means of testing knowledge obtained at training information
I3	Communication with other beings	As a combination of questions and answers to them in the form of a conversation
I4	Heroic transformation	As eveloping Player level / performance and communicate with other players
I5	Travel	Research worlds in space and time

Need for information creates a genre of computer games such as role-playing game (Role-Playing Game – RPG) which provides the player to communicate with the virtual world with the restriction his freedom by the plot of the game (training) or without restrictions, with the full right to move freely (to travel).

These goals of satisfying needs can be combined to form meta-goals as game genres, for example:
– Puzzle (Pazzle), as solving logical problems requiring the player to use logic and intuition = I1 x I2;
– Quest (Quest), as a careful search for hints and hidden details = I2 x I3 or I2 x I4;
– Adventure (Adventure) = I4 x I5;
– Role-playing game (Role-Playing Game – RPG).

The player's need to participate in any actions can be divided into the needs presented in Table 5.

Table 5. Description of Needs for Action

No.	Requirement	Description
A1	Gathering material wealth	Collecting special objects at a small limited level in order to get the highest number of game points
A2	Evasion from dangers	Avoidance enemies, survival, when a player does not have combat skills and he has to avoid encounters with enemies, hide from them and run.
A3	Destruction anything	Destroying everything that moves
A4	competition with other creatures	Confronting competitors (but not enemies) subject to the rules
A5	Direct control	Simulation of the real situation, driving the vehicle

Need for action creates a genre of computer games as a game action *(the Action)* thatcan not take into account the complex simulation models of the real world (collection of material wealth) or fully depend on these models (vehicle control).

These goals address the needs to participate in any activities can be combined to form a meta-goals as the genres of games, for example:

– Platformer (Platformer) = A1 x A2;
– “Hidden action” (Stealth), how to avoid detection of a game character by opponents or covert their removal without attracting attention to yourself = A2 x A3;
– Duel (Fighting) = A3 x A4;
– Race (racing) = A4 x A5.

The player’s need for control can be divided into needs, which are presented in Table 6.

The need for control forms such a basic genre of computer games as a strategy game *(Strategy)*, focused on the process itself or on the results of the process.

These goals of satisfying the needs of control can be combined to form meta-goals of game genres, for example:
– Economic Strategy (Economic) = C1 x C2;
– “Towers” Defense(TowerDefence) = C2 x C3;
– military strategy (wargame) = C3 x C4;
card and collectible board games (Cardgame) = C4 x C5.

Table 6. Description of the player’s control

No.	Needs Requirement	Description
C1	Care for other creatures	For example,game *Tamagotchi*
C2	Creating objects of the surrounding world	Distribution of available resources for development, for example for example, *SimCity*
C3	Indirect control over the objects of the world around the	Player only indicates to the objects what to do without direct control of them.
C4	Tactics	Smooth interaction between the various participants whom the player gives em personal orders
C5	Logic	Planning subsequent actions by the player, for example, in the game *Tetris*

When creating the database *MDA* , the description of three components was used: mechanics, dynamics and aesthetics.

Table 7 shows examples of filling the game aesthetics database.

MDA-component “Mechanics” includes:

– Game-rules – goals rule defining goal of the game – Game components;

– Playrules – rules of manipulation that de termine the main actions that a player can apply in a game.

Table 8 shows examples of filling in the Mechanics Type table.

When creating the Arduino-Sensor Types database, sensor descriptions were used on the official website [68]. An analysis of 203 sensors and other streams was carried out. Sensors are presented in the database, presented in Table 9.

Table 10 presents the results of the step of analyzing the links between the metaphorization functions of the MF set and the game design components of a computer game of the PC, MT, AT sets. The table is a form of representation of the set $R^{(prop)}$, as a result of the execution of the function of mutual mapping of the elements of these sets to each other.

Table 7. Eight types of aesthetics

No.	Type of aesthetics	Description
1	*Sensation*	Game as a feeling of satisfaction, when a player feels something completely unfamiliar, for example, for a player unfamiliar with a game like *RTS* (Real-TimeStrategy), *StarCraft* II could already be a sensation or disappointment due to a number of buttons at the same time, the player, hardened typegames *FPS* have received no sensations, playing for the millionth shooter from the series "World war II" while it does not have a unique game mechanics
2	*Fantasy*	Game as makeup, imaginary world, that is, fantasy is a process c, through which the player spends in the imaginary world and is tied to something that, in his opinion, there can be
3	*Narrative*	Playing like a drama, a story that makes the player re-return to the imaginary world of the game, it is difficult to create for the designer when the target the audience consists of thousands of players, and the designer needs to mentally connect to each
4	*Challenge*	Game as an obstacle, encourages the player to overcome something, to master, increasing the likelihood of reuse of the game
5	*Fellowship*	Game as a social environment, the community in which the player is its active part, part of a cohesive team that n okladayutsya to communicate to the overall success of
6	*Discovery*	Game as unknown territory, calls to explore the game world, the world size should correspond to the dynamics of its components, and the players have to do research on their own, related to various reasons-motivators, such as special equipment, the level of bonuses
7	*Expression*	Play as self-knowledge, his own work, using special characters that come alive in the hands of a player in the process of moving on spec cial areas, and creates a new virtual valuable those
8	*Submission*	Game as a pastime, a connection to the game as such, despite the restrictions, is the most difficult type of aesthetics

Table 8. Example of filling in the Mechanics Type table

No.	Type	Name	Description	Examples
P1	*Play*	*Select*	Invites the player to make multiple selections of elements using any input device (mouse, keyboard, and others)	In adventure games, allows the player to select many items, for example, inventory items or interactive answers using the mouse. In FPS, he chooses different weapons, and in RTS he chooses different buil ings
P2	*Play*	*Write*	Prompts player to enter character-numeric values	In role-playing games allows the player to communicate with other players.
P3	*Play*	*Manage*	Invites the player to manage resources to achieve the goal	For example, invites the player to refuel a car, buy ammunition, purchase materials and tools for building
P4	*Play*	*Random*	Invites the player to defy a chance, try your luck	Many games are used as a way to create random events
P5	*Play*	*Shoot*	Term "Shoot" is not considered in the literal sense, but suggests the player to touch an object located at a distance, or to somehow influence it	For example, in the game "Space Invaders" the player must shoot a rocket, To touch the enemy, without determining his future state
P6	*Play*	*Move*	Invites the player to move in different directions, to control other objects or other characters. 6 directions are possible: forward back, to the left, to the right, up, down	For example, in Action Driving Game, the player is allowed to move the car

Table 8. Continuation

No.	Type	Name	Description	Examples
G1	*Game*	*Create*	Invites the player to show creativity in assembling, building or creating virtual game values	For example, *Crayon Physics* allows the player to draw any object to solve puzzles. This component can also be used to create sound
G2	*Game*	*Destroy*	Antonym component "create". Invites the player: 1) destroy the objects of the game; 2) to catch objects for their further targeted collection and accumulation	For example, in *Space Invaders, a* player needs to destroy every alien in order to win. This component can also be used to collect or catch objects, for example, objects eaten by *Pacman* can be considered “destroyed”, as well as control points in a racing game
G3	*Game*	*Avoid*	Suggests the player to avoid colliding with objects of the game (obstacles, opponents)	For example, in the game *Need for Speed, the* player must avoid collisions with the wall.
G4	*Game*	*Match*	Invites the player to place or hold one or more objects in a certain state	For example, in a Pong game, the player must put the ball out of the control area of his opponent. In the game Chess, the player must place the opponent’s king in a position from which he cannot move

Table 9. Example populate the database Arduino-Sensor Types

No.	Sensor	Description of the sensor
1	Temperature sensor	The sensor measures the ambient temperature
2	Vibration sensor	Measures the presence of vibrations due to the two balls, which during vibration jump through the tube by breaking contact
3	Magnetic field sensor	The sensor measures the presence of the magnetic field received byqithe Hallpu. Sensitive to the polarity of the magnetic field.
4	Soil moisture sensor	The sensor outputs two values depending on how wet the soil is.
5	Light sensor	The sensor contains a photoresistor, which is used to measure the intensity of light or to determine its presence / absence
6	Inclination sensor	The sensor contains a switch that is triggered by the inclination of the module, and reonly takes two positions without measuring the inclination angle
7	Flame sensor	The sensor responds to infrared radiation
8	Impact sensor (shocks)	The sensor when struck perpendicular to the board's plane (shaking) closes
9	Distance sensor	The sensor contains an infrared transmitter and receiver with an effective distance to an obstacle of up to 80 cm and a detection angle of up to 35 °
10	Touch sensor	The sensor includes a metal contact to determine human touch
11	Sound sensor	The sensor includes a microphone with a high sensitivity
12	Gas sensor	The sensor reacts to liquefied petroleum gases, methane, alcohol, Hydrogen, smoke, etc.
13	Rain sensor	The sensor reacts to water droplets
14	Flow sensor	The water flow sensor consists of a water rotor and a Hall sensor. When water passes through the sensor, the rotor rotates at a speed proportional to the speed of water flow. The Hall sensor captures each revolution and transmits the received signal

Table 9. Continuation

No.	Sensor	Description of the sensor
15	Weight sensor	The sensor converts the amount of deformation into an electrical signal
16	Bend sensor	The sensor with a bend produces a proportional increase in resistance at the output
17	UV sensor	The sensor detecting the index of ultraviolet radiation
18	Motion sensor	The sensor contains an infrared sensor and is designed to turn on the light when there is movement in the field of view of the sensor
19	Color sensor	The sensor detects colors according to the main components: Red, Green and Blue

Table 10. Relations between the functions of the metaphorization of the MF (V. Ya. Propp) and game design components of the computer game

MF	Purpose-Base Game Classification (PC)															MDA-Aesthetics (AT)								MDA-Mechanics (AT)									
	Information					Action					Control													Play-rules						Game-rules			
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	6	7	8	1	2	3	4	5	6	1	2	3	4
1					+											+	+	+			+						+		+				
2													+				#	+	+													+	
3																+	#	+	+										+		+		
4		+			+									+		+	#	+			+								+				
5							+											+							+								+
6		+										+					#	+	+							+							
7																	#	+									+		+				
8								+									#	+	+									+		#	+		
9	#	+				#						#				+	#	+			#					#			#	#	#		
10			+										+				#	+		+													+
11																	#	+	+										+				
12					+											+	+	+			+						+		+				
13	#	#	#			#	#	#	#								#	+	+					#					+	#	#	+	
14				+			+										#	+	+													+	
15						+											#	+						+									
16					+												#	+			+								+				
17			#				+	#									#	+	+					#				+			+	+	
18				+									#				#	+							+					+			
19																	#	+													+		
20	+	#				+						+				#	#	+			+					+			+	+	+		
21					+		+										#	+	+										+			+	
22			#	#							#						#	+														+	
23				+													#	+				#		#					+				#
24			+	+										#			#	+				#		#									#
25		#				#	#	#	#								#	+	+					#		#	#		+	#	#	#	
26																	#	+												+			+
27		+		+													#	+				#		+									+
28		+	#	+													#	+				#		+									+
29				+													#	+				+		+	+								+
30								#					#				#	+										+			+		
31				#													#	+												+			

In the course of the analysis, it was revealed that most functions cannot be unambiguously transferred to the semantic field of game mechanics and aesthetics. Thus, the function "*Test*" (MF13) was coded with the aesthetics of "*Challenge*", but at the same time implies a whole set of information needs (I1-3) and actions (A1-4). This function is also necessarily embodied in the Play-rules "*Move*" (test as a hero's progress), which are evaluated in terms of victory - avoid all obstacles (G3 "*Avoid*"). However, the polysemy of the term gives additional and optional mechanics that can implement the function "Test": P1 "*Select*", G1 "*Create*", G2 "*Destroy*".The aesthetic connotations of the "Inflicting Grief" function also lead to Game-rules ambiguity as victory conditions, since the result can be obtained by either the G1 "Create" mechanics or the G2 "Destroy|.

An important aspect of classifying functions of fairy tales with game mechanics is the understanding of the functions themselves as facts without taking into account their consequences. Thus, the function "Shortage" clearly manifests itself in the Needs of NI2 and "as a consequence" is realized in NI1 "Learning", NA1 "Collection of material wealth", NC2 "Creating objects of the world". In Aesthetics, it is clearly realized in "Sensation" (as a feeling of frustration) and leads to "Discovery". In game mechanics, the function "Shortage" can implicitly determine in P3 "Manage", P6 "Move" and G1 "Create".

Thus, the typical functions of metaphorization, which constitute a peculiar form-sample of the game plot, when recoding them into the meaning field of needs, the game mechanic and aesthetics showed such important categories as:

Thus, the typical functions of metaphorization, which constitute a peculiar form-sample of the game plot, when recoding them into the meaning field of needs, the game mechanic and aesthetics showed such important categories as:

1) "multiplicity" (one function means many actions of the game), therefore clear semantic links in the table were marked with a "+" symbol, and implicit interpreters – "#";

2) the complexity of aesthetic connotations (communication "Harm, Grief" – "Create", "Victory" – "Destroy");

3) correlation of the facts (indicated in the table "+") and their consequences ("#");

4) inversion of the "Shortage" functions – "Elimination of the shortage or misfortune";

5) the duplication of functions in the playing field – "Absence", "Departure" – the difference between the meanings of fairy-tale plots in the game is clearly not felt;

6) the absence of the NA5 "Direct control", since the narrative of the fairy tale does not imply the simulation of real situations. Therefore, games invloving the NA5 are a separate genre;

7) "narrative" aesthetics is present in all functions of fairy tales, since they are the basis of the plot;

8) the aesthetics component of "Fantasy" (A2) does not significantly affect the realization of the functions of fairy-tale scenes and can be arbitrarily manifested in all, therefore A2 can be a game add-in defining the entourage of the game world;

9) the components of the aesthetics of "Fellowship" and "Submission" also do not significantly affect the narrative of the game and are implemented separately as independent game add-ins in terms of the number of players (their communication) and the time of game sessions.

Table 11 presents the results of the step of analyzing the links between the elements of a variety of MS types of Arduino microcontroller sensors and the elements of PC, MT and AT sets. The table is a form of representation of the $R^{(sensor)}$ set, as a result of the execution of the function of mutual mapping of the elements of these sets to each other.

In the course of the analysis, it was revealed that sensor gamification is most easily implemented in the "survival" mechanics "Avoid & Match", in components of the aesthetics "Sensation & Challenge". It was also found that the types of MDA components of aesthetics like "Fantasy" and "Narrative" could not be used to gamify the use of sensors.

Testing of the proposed links took place from February 18 to March 1, 2019 in secondary school No.10 with participation of I-III stages' students (Izmail, Odessa region) [77].

The schoolchildren investigated the features of the Arduino UNO microcontroller sensor programming, creating five games: a "Clicker" game with scratch-objects control using a click-button; a game "Get Time for the Barbershop" with the management of scratch-objects using a button and an infrared remote control; the game "Arkanoid" with control of scratch-objects using a potentiometer and a light sensor; the game "Auto lap-racing" with the management of scratch-objects using a potentiometer and buttons; game "Race in the desert" with the management of scratch-objects using two potentiometers.

Table 11. Relations between Arduino sensors and components of the game design of the computer game

MS	Purpose-Base Game Classification (PC)															MDA-Aesthetics (AT)								MDA-Mechanics (AT)									
	Information					Action					Control													Play-rules						Game-rules			
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	6	7	8	1	2	3	4	5	6	1	2	3	4
1	+						+						+			+			+		+								+			+	
2	+						+									+			+		+								+			+	
3	+				+				+							+			+		+								+			+	+
4	+				+						+	+									+					+				+			+
5	+	+					+								+	+			+		+			+		+						+	
6	+				+		+		+	+						+			+		+		+	+					+			+	
7	+						+						+						+					+		+			+			+	
8	+						+	+	+	+						+			+		+		+			+		+			+	+	
9	+				+				+	+			+		+						+							+	+				+
10	+		+							+						+				+				+				+		+	+	+	+
11	+		+													+			+		+			+									+
12	+						+						+						+		+			+									+
13	+						+						+			+			+		+					+			+			+	
14	+						+						+			+			+		+					+			+			+	
15	+			+							+		+			+			+							+				+			+
16	+							+	+				+						+		+					+							+
17	+																																+
18	+				+					+											+		+						+			+	
19	+						+						+			+						+		+		+				+			+

Conclusions and perspectives of further research

The proposed method for establishing two-way communication between the process of designing a computer game using a robot system and the Arduino microcontroller sensors allowed us to create:

– a relational table describing 31 templates of text phrases to create a computer game script that is important for "Arts" component of STREAM, supporting a creative approach to finding solutions to problems and using the possibilities of art when creating products for the user;

– a relational table describing the 15 classes of players' needs, which is important for "Engineering" component of STREAM, accompanying the process of creating prototypes of material products for consumers;

– relational tables describing the 10 classes of MDA-models that are important for the "Mathematics" component of STREAM, providing formalization of the creative processes of designing computer games;

– a relational table describing the 19 Arduino microcontroller sensors, which is important for the "Technology" component of STREAM, providing skills in the use of hardware and software technologies to simplify the procedure for performing manual operations;

– a relational table of interconnections between 31 templates of text phrases of scenarios from the morphological functions of the Fairy Tale by Vladimir Propp and descriptions of 15 classes of players' needs, descriptions of 10 classes of the MDA-model, along with what it was found that most of the functions cannot be unambiguously translated into the semantic field of gaming mechanic and aesthetics, for having multiple inverse relationships;

– a relational table of relationships between the descriptions of the Arduino microcontroller sensors and descriptions of the classes of players' needs descriptions of the classes of the MDA model.

The filling of relational tables of interconnections between sets was performed manually. But in order to reduce the laboriousness of this process, in the future it is planned to introduce information technology of intellectual analysis of source analysis tables, following the example of work [70].

The developed tables were used as methodological recommendations for creating robotic computer games during master classes with participation of
I-III stages' students of secondary school No.10 (Izmail, Odessa region) in the process of creating five

computer games selected taking into account the proposed structural model of 18 projects described in [14], using the Scratch tool software for managing graphic objects based on signals from the Arduino UNO microcontroller sensors. In the process of creating games, schoolchildren solved two types of tasks:

– direct task – determination of gamification characteristics of a given sensor;

– inverse problem – determination of the robotic (Machine-to-Machine) characteristics of a given stage of the computer game design process.

Solving such problems allows schoolchildren to be given the skills, competencies and qualities from the new educational format, Education 4.0.

Returning to Industry 4.0 and its Cyber-Physical Systems, Internet of Things, Smart Factory, Smart Product, Machine-to-Machine, and Big Data, Cloud components, it should be noted that Cyber-Physical Systems, Smart Factory, Smart Product and Machine-to-Machine use finite automaton models. Therefore, after students learn the basics of robotic interaction using visual algorithmic programming in the Scratch tool environment, it is necessary to switch to using visual automaton programming, the advantages of which compared to algorithmic are the simplified analysis of the generated program code and test automation. Unfortunately, modern instrumental development environments for games, such as Unity 3D, that use automate programming are rather complicated for schoolchildren to use. Therefore, in the future we plan to conduct an analysis of the methods and models of automation of game design. These models include the design of games using the software model of finite automaton [71], the mathematical model of Petri nets [72]. A review of the design patterns in games and the feasibility of their use at the design stage [73] will be conducted. We will also consider the method of representing the behavior of a game in the form of predicates of temporal logic based on the calculation of events [74]. These models can be shared with interactive design models, examples of which are Game-O-Matic [75] – a tool for creating video games and a generator for creating games based on ideas using micro-rhetoric; Machination [76] – a game design tool, a framework for designing, balancing and simulating gaming systems.

These interactive design models can also be used in the method proposed in this paper, providing graphical means of displaying the components of the structural model of the method. But this will require the development of a software integration module for the contents of the developed relational database and the internal structures of the software tools supporting these interactive design models.

Acknowledgment

This publication was created with the support of the European Commission Erasmus+KA2-project "GameHub: University-enterprises cooperation in game industry in Ukraine"(№ 561728-EPP-1-2015-1-ES-EPPKA2-CBHE-JP). The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

References

1. Hermann, M., Pentek T. & Otto B. (2016). “Design Principles for Industrie 4.0 Scenarios”. 49-th Hawaii International Conference on System Sciences (HICSS), Koloa, HI, 2016, pp. 3928-3937, doi: 10.1109/HICSS.2016.488.

2. Sarvari, P. A., Ustundag, A., Cevikcan, E., Kaya, I. & Cebi, S. (2018). “Technology Roadmap for Industry 4.0. In: Industry 4.0: Managing The Digital Transformation”. Springer Series in Advanced Manufacturing. Springer, Cham, doi: 10.1007/978-3-319-57870-5_5.

3. Ernst Pessl, Sabrina Romina Sorko and Barbara Mayer. (2017). “Roadmap Industry 4.0 – Implementation Guideline for Enterprises”. International Journal of Science, Technology and Society. Vol. 5, No. 6, 2017, pp. 193-202, doi: 10.11648/j.ijsts.20170506.14.

4. Anealka Aziz Hussin. (2018). “Education 4.0 Made Simple: Ideas For Teaching”. International Journal of Education and Literacy Studies 6(3):92, doi: 10.7575/aiac.ijels.v.6n.3p.92.

5. World Economic Forum Report. (2016). “New Vision for Education: Fostering social and emotional learning through technology” [Electronic resource]. – Access mode : http://www3.weforum.org/docs/WEF_New_Vision_for_Education.pdf.

6. Marina U. Bers, Iri Ponte, Catherine Juelich, Alison Viera & Jonathan Schenker. (2002). “Teachers as Designers: Integrating Robotics in Early Childhood Education”. Information Technology in Childhood Education Annual, (1): 123-145.

7. Atmatzidou, S., Markelis, I. and Demetriadis, S. (2008). “The use of LEGO Mindstorms in elementary and secondary education: game as a way of triggering learning”. Work. Proc. Int. Conf. Simulation, Model. Program. Auton. Robot., pp. 22-30.

8. Avc., B. & Sahin, F. (2019). “The effect of Lego Mindstorm projects on problem solving skills and scientific creativity of teacher candidate”. Inter-

national Journal of Human Sciences. Vol. 16(1), pp. 216-230, doi: 10.14687/jhs.v16i1.5658.

9. Pina, A. & Ciriza, I. (2017). “Primary Level Young Makers Programming & Making Electronics with Snap4Arduino”. In: Alimisis D., Moro M., Menegatti E. (eds) Educational Robotics in the Makers Era. Edurobotics 2016. Advances in Intelligent Systems and Computing, Vol 560. Springer, Cham, doi: 10.1007/978-3-319-55553-9_2.

10. Ospennikova, E., Ershov, M. & Iljin, I. (2015). “Educational Robotics as an Inovative Educational Technology”. Procedia – Social and Behavioral Sciences, 2015, Vol. 214, pp. 18-26, doi: 10.1016/j.sbspro.2015.11.588.

11.Krivonos, O. M., Kuzmenko, E. V. & Kuzmenko, S. V. (2016). Ohlyad ta perspektyvy vykorystannya platformy arduino nano 3.0 u seredniy shkoli [Survey and prospects of arduino nano 3.0 platform use in high school]. Information technology and teaching aids, Vol. 56, No. 6, pp. 77-87 (in Ukrainian).

12. Hoffer, Brandyn M. (2012). “Satisfying STEM Education Using the Arduino Microprocessor” ProQuest Dissertations and Theses; Thesis (M.S.) East Tennessee State University, Publication Number: AAT 1520533; ISBN: 9781267664440; Source: Masters Abstracts International, Volume: 51-02, 220 p.

13. Maria Stergiopoulou, Anthi Karatrantou, Anthi Karatrantou, Christos T. Panagiotakopoulos & Christos T. Panagiotakopoulos. (2017). “Educational Robotics and STEM Education in Primary Education: A Pilot Study Using the H&S Electronic Systems Platform”, Advances in Intelligent Systems and Computing 560: 88-103, doi: 10.1007/978-3-319-55553-9_7.

14. Golikov, Denis. Scratch i Arduino. (2016). 18 proyektov dlya yunykh programmistov. [Scratch i Arduino. 18 proyektov dlya yunykh programmistov], SPb.: BHV-Petersburg, 160 p. (in Russian).

15. Vinnitsky, Yu. A. & Grigoriev, A. T. (2018). Scratch i Arduino dlya yunykh programmistov i konstruktorov [Scratch and Arduino for young programmers and designers]. SPb.: BHV-Petersburg, 176 p. (in Russian).

16. Momot, M. V. (2018). Mobilnye roboty na Arduino. [Mobile robots based on Arduino]. 2-nd ed. SPb. : BHV-Petersburg, 336 p. (in Russian).

17. ScratchX. Play with Experimental Extensions to Scratch! [Electronic resource]. – Access mode : https://scratchx.org/, Title from the screen. – Active link – 01.02.2019.

18. Louis Alfieri, Ross Higashi, Robin Shoo & Christian D Schunn. (2015). “Case studies of a robot-based game to shape interests and hone proportional reasoning skills”, International Journal of STEM Education, 2015, Vol. 2:4, doi: 10.1186/s40594-015-0017-9.

19. Assante, D., Fornario, C., Sayed, A. E. & Salem, S. A. (2016). “Edutronics: Gamification for introducing kids to electronics”, IEEE Global Engineering Education Conference (EDUCON), Abu Dhabi, 2016, pp. 905-908, doi: 10.1109/EDUCON.2016.7474659.

20. Yu, C., Hongkun, Q., Yajie, W., Shuang, L. & Cheng, Q. (2017). “Research on robot based on computer games”. 29-th Chinese Control and Decision Conference (CCDC), Chongqing, 2017, pp. 7649-7653, doi: 10.1109/CCDC.2017.7978575.

21. Kelley, T. R. & Knowles, J. G. (2016). “A conceptual framework for integrated STEM education”, International Journal of STEM Education, 3: 11. DOI: https://doi.org/10.1186/s40594-016-0046-z.

22. Michelle, H. (2013). “Land Full STEAM ahead: The benefits of integrating the arts into STEM”, Procedia Computer Science, No. 3, pp. 547-552.

23. Lefever-Davis, S. & Pearman, C. J. (2015). “Reading, Writing and Relevancy: Integrating 3R's into STEM”, Open Communication Journal, No. 9(1), pp.61-64.

24. Krutiy, K. & Hrytsyshyna, T. (2016). STREAM-osvita doshkil□nykiv: vykhovannya kul□tury inzhenernoho myslennya. [STREAM-education preschoolers: educate the culture of engineering thinking]. Preschool education, No. 1, pp. 3-7 (in Ukrainian).

25. Hamari, J., Koivisto, J. and Sarsa, H. (2014). “Does Gamification Work?” – A Literature Review of Empirical Studies on gamification, In proceedings of the 47-th Hawaii International Conference on System Sciences, Hawaii, USA, January 6-9, 2014, pp. 3025-3034.

26. Blazhko, O., Luhova, T., Melnik S. & Ruvinska, V. (2017). “Communication Model of Open Government Data Gamification Based on Ukrainian Websites”, 4-th Experiment@ International Conference (exp.at'17) June 6-th – 8-th, 2017, University of Algarve, Faro, Portugal, pp. 181-186.

27. Bouras, C., Igglesis, V., Kapoulas, V., Misedakis, I., Dziabenko, O., Koubek, A., Pivec, M. & Sfiri A. (2005). “Game-Based Learning Using Web Technologies”, International Journal of Intelligent Games and Simulations, No. 3(2), pp. 70-87.

28.“Deeper learning competencies” [Electronic resource]. – Access mode : https://www.hewlett.org/wpcontent/uploads/2016/08/Deeper_Learning_Defined__April_2013.pdf. – Active link – 03.12.2018.

29. Blazhko, O., Gdowska, K., Gawel, B., Dziabenko, O. & Luhova, T. (2017). "Deeper-learning approaches integrated in serious games", Project, Program, Portfolio Management. P3M. In The Proceedings of the International Research Conference, Vol. 2, pp. 18-21, December. – Available at : http://dspace.opu.ua/jspui/handle/123456789/6866.

30.Gee James, P. (2018). "What Video Games Have to Teach Us about Learning and Literacy", [Electronic resource]: – Access mode : http://newlearningonline.com/literacies/chapter-2/gee-on-what-video-games-have-to-teach-us-about-learning-and-literacy. – Active link – 03.12.2018.

31. Gdowska, K., Gaweł, B., Dziabenko, O. & Blazhko, O. (2018). „Gamification in teaching humanities – „GameHub" project", V E-technologie w działaniach edukacyjnych w projekcie GameHub V Konferencja e-Technologie w Kształceniu Inżynierów Akademia Górniczo-Hutnicza im. Stanisława Staszica w Krakowie, Kraków, 19-20 kwietnia 2018, pp. 27-32.

32. Adams, E. (2014). "Fundamentals of Game Design", New Riders, 560 p.

33. Sandhya Devi Gogula & Chanakya Puranam. (2015). "Augmented Reality in Enhancing Qualitative Education", International Journal of Computer Applications, Vol. 132, No.14, pp. 41-45.

34. Dormans, J. (2012). "Engineering emergence: applied theory for game design". PhD. thesis 13. 288 p. – Available at : http://hdl.handle.net/11245/1.358623.

35. Hunicke, R., LeBlanc, M. \\\\7 Zubec, R. (2004). *MDA:* "A formal approach to game design and gameresearch" In: Proceedings of the AAAI Workshop on Challenges in Game AI. Vol. 4.

36. Winn, B. (2009). "The Design, Play, and Experience Framework. Handbook of Research on Effective Electronic Gaming in Education". Richard Ferdig (editor). Volume 3, Chapter 58.

37. Luhova, T. A. & Blazhko, O. A. (2018). Rozrobka navchal□nykh video ihor, zasnovanykh na aktyvizatsiyi neyavnykh znan□. [Development of educational video games based on the activation of implicit knowledge]. Management of Development of Complex Systems. No. 35, pp. 105-112 (in Ukrainian).

38. Blazhko, O. A., Antonyuk, V. V., & Troyanovska, Y. L. (2018). Instrumental□ni osoblyvosti avtomatychnoho prohramuvannya komp'yuternykh ihor. [Instrumental Features of Automata-Based Programming of Computer Games]. Management of Development of Complex Systems, No. 35, pp. 83-92 (in Ukrainian).

39. Damien Djaouti, Julian Alvarez, Jean-Pierre Jessel, Gilles Methel & Pierre Molinier. (2008). "A Gameplay Definition through Videogame Classification", International Journal of Computer Games Technology, doi: 10.1155/2008/470350.

40. David Weintrop and Uri Wilensky. (2017). "Comparing Block-Based and Text-Based Programming in High School Computer Science Classrooms". ACM Trans. Comput. Educ. 18, 1, Article 3 (October 2017), 25 p.

41. Louise P. Flannery, Brian Silverman, Elizabeth R. Kazakoff, Marina Umaschi Bers, Paula Bontá and Mitchel Resnick. (2013). "Designing ScratchJr: Support for early childhood learning through computer programming". In Proceedings of the 12-th International Conference on Interaction Design and Children. ACM, pp. 1-10.

42. Neil Fraser. (2015). "Ten things we've learned from Blockly". In Proceedings of the 2015 IEEE Blocks and BeyondWorkshop (Blocks and Beyond), pp. 49-50.

43. David Wolber, Hal Abelson, Ellen Spertus and Liz Looney. (2014). "App Inventor 2: Create Your Own Android Apps". 2-nd ed. Beijing: O'Reilly Media.

44. Jared, St. J. (2012). "Kinect Hacks Tips & Tools for Motion and Pattern Detection", *Publisher: O'Reilly Media,* 280 p.

45. Blazhko, O. A. & Ryashchenko, O. I. (2018). Osoblyvosti STREAM-osvity na osnovi rozrobky rozvyvayuchykh komp`yuternykh ihor z vykorystannyam sensoriv kontrolyu rukhiv lyudyny MS KINECT. [Features of STREAM-Education Based on Computer Game Development by using Human Motion Sensor MS Kinect]. Procs. of III International scientific-practical conference P3M-2018 Project, Program, Portfolio Management, 7-8 hrudnya, 2018, Odesa, Ukrayina, Odesa : Balan V. O., No. 2/1, pp. 11-14 (in Ukrainian).

46. Ryashchenko O. I. & Blazhko O. A. (2018). Metodyka stvorennya real□no dopovnenoyi virtual□nosti trenuval□nykh vprav z m□yachem na osnovi sensornoho kontroleru rukhu MS Kinect. [Method of implementation of really augmented virtuality of training with the ball by using sensor motion controller MS Kinect]. Procs. of the I International Scientific and Practical Conference "Imperatives of Civil Society Development in Ensuring National Competitiveness", Vol. 1, 13-14 december, 2018, Batumi, Gergia, Batumi : *Publishing House "Kalmosani"*, 2018, pp. 208-210 (in Ukrainian).

47. “Lumoplay” [Electronic resource]: – Access mode : https://www.lumoplay.com. – Active link – 01.02.2019.

48. “MotionMagix” [Electronic resource]: – Access mode : http://www.motionmagix.com/. Active link – 01.02.2019.

49. “MetaVerse” [Electronic resource]: – Access mode : https://gometa.io/. – Active link – 03.12.2018.

50. “Some examples of the more than 1300 soccer exercises in our database” [Electronic resource]: – Access mode : https://www.footballtraining4all.com/en-gb/exercises.aspx – Title from the screen. – Active link – 01.02.2019.

51. Jere Miles. (2016), “Unity 3D and PlayMaker Essentials: Game Development from Concept to Publishing” (Focal Press Game Design Workshops) Paperback, *Publisher: A K Peters/CRC Press,* 506 p.

52. “Meet and Code 2018 in Odessa at ONPU “ [Electronic resource] : – Access mode : https://youtu.be/IjdOTClEM1M – Title from the screen. – Active link – 01.02.2019.

53. “Meet and Code 2018 in Izmail at School No. 10” [Electronic resource]: – Access mode : https://youtu.be/1ha19XVm7KQ – Title from the screen. – Active link – 01.02.2019.

54.“The Periodic Table of Storytelling” [Electronic resource]: – Access mode : http://jamesharris.design/periodic/ – Title from the screen. – Active link – 01.02.2019.

55. Gumennykova Tamara, Luhova Tatiana, Riashchenko Oksana & Troianovska Yuliia. (2018). “Integration of the process of computer game development with augmented reality in STREAM-education components”. Herald of Advanced Information Technology, No. 01(01), pp. 49-61, doi: 10.15276/hait 01.2018.5.

56. Melnik, S. P. & Lozhan, E. O. (2017). Komp'yuternaya igra kak kommunikatsiya. [Computer Game as Communication]. Modern Information Technologies 2017 (MIT-2017): Materials of the Seventh International Conference of Students and Young Scientists, 22-24 May 2017 Ministry of Education and Science of Ukraine, Odessa National Polytechnic University, Odessa: Bondarenko M. O., 2017, pp. 218-219 (in Ukrainian).

57. Melnik, S. (2014). Osoblyvosti manipulyatyvnoho aspektu mifolohichnoyi komunikatsiyi, [Features of the manipulative aspect of mythological communication]. Odesa: FOP Grin D. S., No. 4 (41), pp. 55-59 (in Ukrainian).

58. Blazhko, O. A., Lugovaya T. A. &Melnyk, S. P. (2017). Pravila komp'yuternykh igr-gistogramm so statisticheskimi otkrytymi dannymi. [Rules of computer game-histogram with statistical open data]. V Ukrainian-German conference Informatics. Culture. Technique: Collection of abstracts (22.05-26.05.2017, Odessa, Ukraine), Odessa: ONPU, pp. 87-90 (in Russian).

59. Pocheptsov, G. G. (2001). Russkaya semiotika, [Russian semiotics]. Moscow : “Relay-beech”, Kiev : “Wackler”, 768 p. (in Russian).

60. “MBlock. Programming software designed for STEAM education”. [Electronic resource]: – Access mode : http://www.mblock.cc/ – Title from the screen. – Active link – 01.02.2019.

61. “Scratch for Arduion. S4A” [Electronic resource]: – Access mode: http://s4a.cat/ – Title from the screen. Active link – 01.02.2019.

62. El-laithy, R. A., Huang J. & Yeh M. (2012). “Study on the use of Microsoft Kinect for robotics applications”. Proceedings of the 2012 IEEE/ION Position, Location and Navigation Symposium, Myrtle Beach, SC, 2012, pp. 1280-1288, doi: 10.1109/PLANS.2012.6236985.

63. “Serios Game Classification” [Electronic resource]: – Access mode : http://serious.gameclassification.com/. – Active link – 01.02.2019.

64.“Klassifikatsiya zhanrov komp'yuternykh igr” [Electronic resource]: – Access mode : http://gamesisart.ru/janr.html. – Active link – 01.02.2019 (in Russian).

65. Maslow, A. H. (1943). “A theory of human motivation. Psychological” Review. 50 (4): 370-96. doi:10.1037/h0054346.

66. Speranskyy Viktor, & Kravchenko Ihor. (2018). “Cross-platform practices for mobile application development of automated trade accounting”. Scientific Journal Applied Aspects of Information Technology, No. 01(01), pp. 48-58, doi: 19.15276/aait.01.2018.3.

67. Luhova Tatiana, & Blazhko Oleksandr. (2018). “Features of using the canvas-oriented approach to game design”. Scientific Journal Applied Aspects of Information Technology, No. 01(01), pp. 66-77 doi: 19.15276/aait.01.2018.5.

68. Arduino datchyky [Arduino Sensors] Arduion Sensors [Electronic resource]: – Access mode : https://arduino.ua/index.php?categoryID=6. – Active link – 01.02.2019 (in Russian).

69. Gogunskii Viktor, Kolesnikov Olexii, Lykianov Dmytro & Sherstyuk Olga. (2018). “The use of the “design-thinking” and “seven hats” methods at the project initiation and planning stage”. Herald of Advanced Information Technology, No. 01(01), pp. 62-68, doi: 10.15276/hait.01.2018.6.

70. Arsirii Olena, Babilunha Oksana, Manikaeva Olga & Rudenko Oleksii. (2018). “Automation of the Preparation Process Weakly-Structured Multi-Dimensional Data Of Sociological Surveys in the Data Mining System”, Herald of Advanced Information Technology, No. 01(01), pp.11-29, doi: 10.15276/hait.01.2018.1.

71. Polikarpova, N. I. & Shalyto, A. A. (2010). Avtomatnoye programmirovaniye [Automatic programming]. 2-nd ed., SPb . : *Peter. Publ*., 176 p. (in Russian).

72. Araujo Manuel & Roque Licinio. (2009). “Modeling Games with Petri Nets. Breaking New Ground: Innovation in Games, Play”, Practice and Theory – Proceedings of DiGRA 2009.

73. Staffan Björk & Jussi Holopainen. (2004). “Patterns in Game Design. Charles River Media”.

74. Adam M. Smith, Mark J. Nelson & Michael Mateas. (2009). “Computational support for play testing game sketches”. In Proceedings of the 5-th Artificial Intelligence and Interactive Digital Entertainment Conference, pp. 167-172.

75. Mike Treanor, Bryan Blackford, Michael Mateas & Ian Bogost. (2012). “Game-O-Matic: Generating videogames that represent ideas”. In Proceedings of the 2012 Workshop on Procedural Content Generation.

76. Joris Dormans. (2009). “Machinations: Elemental feedback structures for game design”. In Proceedings of GAMEON-NA 2009, pp. 33-40.

77. Master-klass po igrovoy robototekhnike v Izmaile [Master-class on gaming robotics in Ismail] [Electronic resource]: – Access mode : https://www.facebook.com/permalink.php?story_fbid=2077630549021474&id=100003236477275 – Title from the screen. – Active link – 01.03.2019 (in Ukrainian)

Received 28.01.2019

[2]**Гуменникова Тамара Рудольфівна,** доктор педагогічних наук, професор кафедри суспільно-наукових дисциплін, E-mail: gumennikova100@gmail.com , ORCID: 0000-0002-6223-7711
[1]**Блажко Олександр Анатолійович**, кандидат технічних наук, доцент, доцент кафедри системного програмного забезпечення, E-mail: blazhko@ieee.org , ORCID: 0000-0001-7413-275X
[1]**Лугова Тетяна Анатоліївна**, кандидат мистецтвознавства, доцент кафедри інформаційної діяльності та медіа-комунікацій, E-mail: lug2308@gmail.com, ORCID: 0000-0002-3573-9978
[1]**Трояновська Юлія Людвігівна**, старший викладач кафедри інформаційних систем, E-mail: troyanovskaja@gmail.com, ORCID: 0000-0002-6716-9391
[1]**Мельник Сергій Петрович**, кандидат наук із соціальних комунікацій, доцент, E-mail: miroschnick@ukr.net, ORCID: 0000-0003-3996-9970
[3]**Рященко Оксана Іванівна**, вчитель інформатики, E-mail: oksanaivanovna561@gmail.com, ORCID: 0000-0002-9242-0752
[1]Одеський національний політехнічний університет, Одеса, Україна
[2]Придунайська філія Приватного акціонерного товариства «Вищий навчальний заклад «Міжрегіональна Академія управління персоналом», Ізмаїл, Україна
[3]Загально-освітня школа № 10, Ізмаїл, Україна

ОСОБЛИВОСТІ ГЕЙМІФІКАЦІЇ РОБОТОТЕХНІЧНОЇ STREAM-ОСВІТИ

Анотація. *У статті обговорюється зростання вимог сучасних виробничих компаній до якості кадрового забезпечення з урахуванням появи терміна Industry 4.0, що включає компоненти: Cyber-Physical Systems, Internet of Things, Smart Factory, Internet of Services, Smart Product, Machine-to-Machine, Big Data, Cloud. Відзначається важливість впровадження в такі освітні напрямки для школярів як STEM (S - Science, T - Technology, E - Engineering і M - Mathematics), STEAM (додавання A - Arts) і STREAM (додавання R - Reading / Writing) з використанням робототехнічних інструментів , наприклад, на основі електронної платформи з мікро контролером Arduino. Але сьогодні вони не враховують способу мотиваційну діяльність на основі комп'ютерних ігор, тому метою статті стало встановлення двосторонніх зв'язків між процесом проектування комп'ютерної гри, що використовує робототехническую систему, і датчиками мікроконтролера Arduino для подальшого вирішення завдання визначення гейміфікаціонних характеристик заданого датчика, а також завдання визначення робототехнічних характеристик заданого етапу процесу проектування комп'ютерної гри. Для досягнення зазначеної мети запропонована методика аналізу даних, що включає наступні етапи. Етап аналізу функцій казкових сюжетів по В.Я. Проппу (надалі, функції метафоризації), який формує таблицю функцій як текстових фраз-шаблонів для створення сценарію комп'ютерної гри, яка враховує датчики мікроконтролера Arduino. Етап аналізу класів комп'ютерних ігор, який формує таблицю класів ринку збуту гри і таблицю класів потреб гравців. При цьому передбачається, що ринок збуту продукту тісно пов'язаний з різними дисциплінами шкільної програми. Етап аналізу компонент Механіка-Динаміка-Естетика MDA-моделі. Етап аналізу датчиків мікроконтролера Arduino. Запропонована в роботі методика дозволила створити реляційну базу даних, що включає таблиці: таблицю опису 31 текстових фраз-шаблонів для створення сценарію комп'ютерної гри; таблицю опису 15 класів потреб гравців; таблицю опису 10 класів MDA-моделі таблицю опису 19 датчиків мікроконтролера Arduino; таблицю зв'язків між 31 текстовими фразами-шаблонами сценаріїв з морфологічних функцій чарівної казки В.*

Я. Проппа і описами 15 класів потреб ігроков¸ а також описами 10 класів MDA-моделі; таблицю зв'язків між описами датчиків мікроконтролера Arduino і описами класів потреб ігроков¸ а також описами класів MDA-моделі. Апробація запропонованої методики пройшла під час проведення майстер-класів за участю школярів загальноосвітньої школи № 10 I-III ступенів м Ізмаїл Одеської області в процесі створення п'яти комп'ютерних ігор з використанням інструментальної програмної середовища Scratch з управління графічними об'єктами на основі сигналів від датчиків мікроконтролера Arduino UNO . В майбутньому пропонується розглянути інтерактивні моделі проектування робототехнічних комп'ютерних ігор, які можуть бути використані в запропонованій в даній роботі методикою, надаючи графічні засоби відображення компонент структурної моделі методики. І, як наслідок, це зажадає розробки програмного модуля інтеграції вмісту розробленої реляційної бази даних і внутрішніх структур програмних інструментів підтримки зазначених інтерактивних моделей проектування.

Ключові слова: *STREAM-освіта; навчальні роботи; Arduino, комп`ютерна гра*

[2]**Гуменникова Тамара Рудольфовна**, доктор педагогических наук, профессор кафедры общественно-научных дисциплин, E-mail: gumennikova100@gmail.com, ORCID: 0000-0002-6223-7711

[1]**Блажко Александр Анатольевич**, кандидат технических наук, доцент, доцент кафедры системного программного обеспечения, E-mail: blazhko@ieee.org, ORCID: 0000-0001-7413-275X

[1]**Луговая Татьяна Анатольевна**, кандидат искусствоведения, доцент кафедры информационной деятельности и медиа-коммуникаций, E-mail: lug2308@gmail.com, ORCID: 0000-0002-3573-9978

[1]**Мельник Сергей Петрович**, кандидат наук по социальным коммуникациям, доцент, E-mail: miroschnick@ukr.net, ORCID: 0000-0003-3996-9970

[1]**Трояновская Юлия Людвиговна**, старший преподаватель кафедры информационных систем, E-mail: troyanovskaja@gmail.com, ORCID: 0000-0002-6716-9391

[3]**Рященко Оксана Ивановна**, учитель информатики, E-mail: oksanaivanovna561@gmail.com, ORCID: 0000-0002-9242-0752

[1]Одесский национальный политехнический университет, Одесса, Украина

[2]Придунайский филиал Частного акционерного общества «Высшее учебное заведение «Межрегиональная Академия управления персоналом», Измаил, Украина

[3]Общеобразовательная школа № 10 Измаил, Украина

ОСОБЕННОСТИ ГЕЙМИФИКАЦИИ РОБОТОТЕХНИЧЕСКОГО STREAM-ОБРАЗОВАНИЯ

Аннотация. *В статье обсуждается рост требований современных производственных компаний к качеству кадрового обеспечения с учетом появления термина Industry 4.0, включающий компоненты: Cyber-Physical Systems, Internet of Things, Smart Factory, Internet of Services, Smart Product, Machine-to-Machine, Big Data , Cloud. Отмечается важность внедрения в такие образовательные направления для школьников как STEM (S - Science, T - Technology, E - Engineering и M - Mathematics), STEAM (добавление A - Arts) и STREAM (добавление R - Reading/Writing) с использованием робототехнических инструментов , например, на основе электронной платформы с микроконтроллером Arduino. Но сегодня они не учитывают способы мотивационной деятельности на основе компьютерных игр, поэтому целью статьи стало установление двусторонних связей между процессом проектирования компьютерной игры, использующей робототехническую систему, и датчиками микроконтроллера Arduino для дальнейшего решения задачи определения геймификационних характеристик заданного датчика, а также задачи определения робототехнических характеристик заданного этапа процесса проектирования компьютерной игры. Для достижения указанной цели предложена методика анализа данных, включающая следующие этапы. Этап анализа функций сказочных сюжетов по В. Я. Проппу (в дальнейшем, функции метафоризации), который формирует таблицу функций как текстовых фраз-шаблонов для создания сценария компьютерной игры, учитывающий датчики микроконтроллера Arduino. Этап анализа классов компьютерных игр, который формирует таблицу классов рынка сбыта игры и таблицу классов потребностей игроков. При этом предполагается, что рынок сбыта продукта тесно связан с различными дисциплинами школьной программы. Этап анализа компонент Механика-Динамика-Эстетика MDA-модели. Этап анализа датчиков микроконтроллера Arduino. Предложенная в работе методика позволила создать реляционную базу данных, включая таблицы: таблицу описания 31 текстовых фраз-шаблонов для создания сценария компьютерной игры; таблицу описания 15 классов потребностей игроков; таблицу описания 10 классов MDA-модели, таблицу описания 19 датчиков микроконтроллера Arduino, таблицу связей между 31 текстовыми фразами-шаблонами сценариев из морфологических функций волшебной сказки В. Я. Проппа и описаниями 15 классов потребностей игроков¸ а также описаниями 10 классов MDA-модели, таблицу связей между описаниями датчиков микроконтроллера Arduino и описаниями классов потребностей игроков¸ а также описаниями классов MDA-модели. Апробация предложенной методики прошла во время проведения мастер-классов с участием школьников общеобразовательной школы № 10 I-III ступеней г. Измаил Одесской области в процессе создания пяти компьютерных игр с использованием инструментальной программной среды Scratch по управлению графическими объектами на основе сигналов от датчиков микроконтроллера Arduino UNO. В будущем предлагается рассмотреть интерактивные модели проектирования робототехнических компьютерных игр, которые могут быть использованы в предложенной в данной работе методике, предоставляя графические средства отображения компонент структурной модели методики. И, как следствие, это потребует разработки программного модуля интеграции содержания разработанной реляционной базы данных и внутренних структур программных инструментов поддержки указанных интерактивных моделей проектирования.*

Ключові слова: *STREAM-образование; учебные роботы, Arduino, компьютерная игра*