The object of this study is the process of forming recommendations for adolescents regarding their choice of profession based on performance in a multi-level, profession-oriented computer game. The problem addressed is the gamification of adolescents' professional self-identification A multilayer perceptron with two sequential hidden layers of 32 and 16 nodes has been proposed to generate recommendations in real time. The task is formulated as a categorization problem using game performance data, including interest level, learning readiness, time spent, and the number of attempts for level completion. The neural network design allows integration with various games and expansion of the training dataset. Combining "time" and "number of attempts" ensures the accuracy and efficiency of the training process, mitigating evaluation bias caused by users guessing strategies through frequent attempts. Experts validate the game's alignment with professional qualification requirements and assess adolescents' readiness to acquire necessary competencies. Abilities are evaluated by comparing the gameplay parameters of users with those of specialists. The specialist's results serve as benchmarks to normalize data, forming the basis for recommendations. Unlike previous approaches, this study accounts for both the time taken to complete each level and the number of attempts, ensuring fairer evaluations. The practical significance of the work is to offer users accessible tools for career decision-making through engaging in profession-oriented games. The neural network model has the potential for implementation in career guidance systems, provided the training dataset is expanded and the system undergoes additional testing under a trial mode for refinement and adaptation

Keywords: multilayer perceptron, gamification of career guidance, real-time electronic assessment

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GAMIFICATION OF DECISION SUPPORT PROCESS FOR ADOLESCENTS' CAREER CHOICE

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1. Introduction

Research into the modern educational environment and the analysis of psychosocial factors related to the participation of adolescents in education and employment [1] have revealed a loss of interest in learning among students of all age groups. One of the main reasons for the decrease in motivation is the lack of a clear understanding of the purpose of learning as the acquisition of knowledge and skills that will be useful to the student in their future professional activity. At the same time, self-esteem and aspirations of adolescents are identified as two of the main areas of behavioral problems that require additional research.

At the same time, it is shown in [2, 3] that interest in future professional activity increases interest in acquiring knowledge and skills in the specialty, which in turn significantly increases the competitiveness of graduates. This means that professional identification is an important issue of self-actualization in professional activity and personal self-determination, and improving the career guidance process contributes to solving an important social problem of improving the quality of future life of modern youth.

To provide adolescents with qualified support in choosing a profession, various career guidance activities are carried out in different countries and various online services are developed. The experience of introducing the subject "Choosing the Future" in schools shows that the approach to career guidance activities based on interviews with adolescents has an advantage in identifying personal interests and abilities. However, career counseling in schools requires the involvement of significant human resources and special training of specialists who are to teach this subject [4].

Unlike the use of career guidance support tools, which require the involvement of career counseling specialists, the use of online services allows adolescents to self-assess their knowledge and abilities. Self-assessment questionnaires offered by online services take into account the perspective of students based on an assessment of their abilities and competencies of a graduate of an educational institution, provided that the questions are correctly selected. However, support for the decision to choose a profession involves the assessment of special abilities, which are determined by the set of competencies of a graduate of an educational institution [5].

In addition, one of the main disadvantages of questionnaire assessment of adolescents' abilities is considered to be the loss of interest in the assessment process due to [6]:

– the duration of processing the results;

– the lack of quick feedback;

– the lack of adaptability of online services currently used.

Among other problems that still need to be solved [5] are:

– the usually subjective nature of adolescents' responses to questionnaire questions;

– the risk of error due to a fuzzy idea of future professional activity;

– the lack of mechanisms for self-assessment of interests and abilities, which make it possible to reduce the level of fuzzy uncertainty in real time.

Career guidance work with an objective assessment of the results of performing computer game tasks of professional orientation in real time, in contrast to questionnaire testing, is one of solutions [6, 7]:

– creating favorable interactive conditions for awareness of professional interests and abilities without unnecessary pressure from outsiders and stress from responsibility for a decision made under conditions of uncertainty;

– overcoming uncertainty associated with a fuzzy idea of the future profession and the lack of a clear assessment of abilities to perform professional activities;

– solving the social problem of staff turnover, which causes an imbalance of demand and supply in the labor market and an increase in costs for training and retraining of specialists in various industries;

– reducing the involvement of human resources in the process of career guidance work and the associated long-term profit due to savings in funds for conducting career guidance activities, as well as training and salaries of career consultants;

– obtaining environmental profit by saving paper, which is still unjustifiably massively used in the advertising activities of educational institutions;

– obtaining economic profit by using existing professionally oriented games.

Thus, in the context of adapting educational institutions to the requirements and desires of modern adolescents, who are called digital natives [8], scientific research aimed at gamification of career strategies and the process of career guidance is relevant.

2. Literature review and problem statement

Modern digital technologies are increasingly penetrating the field of education and transforming traditional approaches to learning and assessing knowledge, and gamification of education is the subject of active research.

Analysis of innovative transformations in modern education, conducted in [9], revealed that despite the use of the concept of "gamification" in the scientific literature since 2010, the interpretation of this term has not yet been established.

In works aimed at studying the potential of gamification to expand conventional learning through the use of gaming activities in the real world, gamification is considered as:

– a partial solution to the problem of reduced motivation by involving students at modern schools in video game activities in online learning [4, 10];

– updating the educational paradigm with the advantage of interactive learning and training of certain skills through the introduction of games, gaming techniques, and gaming practices for educational purposes [11–13].

– implementation of a competent approach for students of specialized classes at secondary [14] and higher education institutions [15], which contributes to the development of the ability to work in a team and introduces an element of curiosity into professional and educational activities.

However, the use of gaming technologies to assess a person's professional abilities is not considered in these works since it involves not only determining the level of knowledge and skills using video game activities. To assess professional abilities through the gaming process, it is necessary to formalize such behavioral characteristics of the individual as the strategy for solving tasks during the game. Currently, this problem remains unresolved due to the lack of approaches to analyzing game data that would allow interpreting the results of a teenager's game as a reliable indicator of a person's professional abilities.

Study [16] describes computer-assisted career guidance systems (CACGS), which do not require personal consultations and can reduce the cost of career consultants. Currently, CACGS are already used to solve career planning issues. However, these systems do not fully solve the issue of career guidance since career planning requires long-term tracking of the results of decisions made at the stage of choosing a profession. In addition, young people do not have an incentive to use CACGS since they subconsciously avoid the issue of employment. Therefore, in [16], game-assisted learning is proposed to increase motivation, which is aimed at improving self-understanding and encouraging young people to pursue vocational training that they will enjoy.

Thus, in [16], an attempt is made to recreate an interesting and effective career guidance system using games that can replace counseling and coaching, turning them into games, which will help young people understand their future career through games. However, the work does not describe how CACGS can be used to support decisions in cases where a young person cannot make a choice from a set of acceptable alternatives.

In [17], the process of assessing the abilities to work in the field of logistics is described, which is based on comparing the success of performing professionally-oriented computer tasks before and after training. This approach makes it possible to solve the problem of personnel turnover in one field of activity if the choice of activity has already been made. However, other professions in which the teenager may have greater interest and better abilities are left out of consideration.

In [18], the processes of creating a knowledge base are described, which is used by the fuzzy inference system when generating a recommendation conclusion on the appropriateness of choosing a future profession based on the results of computer games. At the same time, expert rules take into account the nature of errors made when performing tasks of different levels. But the work remained at the level of theoretical proposals. In addition, in [18], the issue of assessing the degree of interest in professional activity remained unresolved.

Expert assessment of the degree of interest and professional abilities of an individual according to the clear criterion of "time" spent on the selection and performance of professionally oriented tasks of a computer game was considered in [19]. However, this solution was also not implemented.

In [18, 19], the issue of taking into account the number of attempts used to complete tasks was not resolved, and this issue is extremely important when choosing a profession, which requires making the right decision on the first attempt. Another significant drawback of the approach based on fuzzy inference systems is the formation of an a priori knowledge base for all scenarios of different games. At the same time, changing the number of game levels and rules regarding the impact of an error on the game result requires manual updating of the rule base, which takes a lot of time and creates a precedent for human errors.

This provides grounds for research on neural networks capable of solving the following problems:

– multivariate regression, which is the prediction of professional abilities based on the results of a multilevel computer game;

– fuzzy categorization, which is the assignment to a certain class of the overall result of a teenager's game, formed during the game.

The choice of a neural network capable of solving the problems of multivariate regression and fuzzy categorization is significantly influenced by the method of its training, therefore, in this work, the main methods of training neural networks used to solve these problems in other fields were initially studied.

As a result of the study of unsupervised and supervised learning and reinforcement learning [20, 21], it was decided to use supervised learning. Such a decision is, first of all, justified by the impossibility of providing a sufficiently reliable recommendation regarding the teenager's ability to perform a certain activity based on a set of characteristics of their personality without the help of career consultants. In addition, the decision to use supervised learning was influenced by the working conditions of modern domestic educational institutions, which significantly complicate the acquisition of a sufficient amount of statistical data for unsupervised learning of a neural network.

After determining the learning method, only those neural networks that are used in regression and categorization tasks and support supervised learning were considered. The list of neural networks that meet these requirements includes fuzzy neural networks of the adaptive resonance theory and Takagi-Sugeno-Kanga categories, convolutional and recurrent neural networks, decision trees, gradient boosting, and multilayer perceptron (MLP).

Analysis of the experience of using the above-mentioned neural networks in solving various categorization and regression problems revealed that the possibility of using adaptive resonance theory and Takagi-Sugeno-Kanga neural networks to assess the special abilities of applicants was investigated in [18, 19].

The weakness of those studies is the need to manually form an a priori rule base for clearly defined scenarios of various games. This means that when the number of game levels changes, the number of rules also changes. In such cases, it is necessary to manually remove or add rules and update the a priori knowledge base of the system, which takes a lot of time and creates the potential for human errors. In addition, in [18, 19], the problem of mapping the expert knowledge base to the memory map of neural networks remained unsolved.

In [22], the possibility of using MLP neither for assessing the abilities of adolescents nor for generating a recommendation conclusion based on the results of computer games is considered; however, the study shows the advantages of MLP in solving regression and categorization problems, which is provided by its:

– simplicity of structure, which is well suited for data sets with a fixed input size, if the relationships between features are not too complex;

– universality of approximation, which, with a sufficient number of neurons and layers, can approximate any function and makes MLP a good choice when the exact function between the input and output data is unknown;

– nonlinearity, which provides the opportunity to model nonlinear relationships between input and output data using ReLU [23], if the data do not have a linear dependence on time and the number of attempts;

– fixed structure, free from sequential or spatial dependences;

– scalability on large data sets, enabling the use of hardware acceleration such as GPUs.

Research conducted in [22] showed that MLP can handle both categorization and regression by using different output layers and loss functions. At the same time, the fixed structure and scalability simultaneously make MLP the simplest and most effective when the data set grows without complicating the model. MLP is also a simple and effective choice for studying the relationships between numerical input data reflecting the results of performing tasks of different levels.

Thus, the ability of MLP:

– to classify can provide an answer to the question: "Should a teenager be recommended a certain profession?";

– to solve the regression problem will help find an answer to the question: "What level of abilities to perform a certain operational activity did the teenager show when performing the tasks of the corresponding game?".

However, supervised learning of MLP first requires formalization of the process of generating a conclusion about the appropriateness of choosing a profession based on estimates of the degree of interest, time and number of attempts used when performing the tasks of a professionally oriented computer game. This will provide experts with the opportunity to:

– substantiate the assessment of such fuzzy characteristics of a teenager's personality as the degree of interest and professional abilities;

– evaluate the results of completing tasks at each level and based on these assessments, form a portrait of a specialist;

– monitor (analyze and correct) the work of MLP.

3. The aim and objectives of the study

The purpose of our study is to devise an approach to generating a recommendation conclusion on the appropriateness of choosing a profession by a teenager based on the evaluation of the parameters of their interaction with a professionally-oriented computer game.

This will make it possible to:

– reduce the risk of error due to a fuzzy idea of professional activity by familiarizing the teenager with operational activities reproduced in a computer game;

– overcome the subjectivity of the questionnaire assessment of professional abilities;

– prevent loss of interest in the process of assessing professional abilities.

To achieve the goal, the following tasks were set:

– to formalize the process of generating a conclusion on the appropriateness of choosing a profession based on the evaluation of the degree of interest, time, and number of attempts used when performing tasks in a professionally-oriented computer game based on MLP;

– to propose a design of MLP capable of integrating with existing multi-level computer games;

– to experimentally test the ability of MLP to form a reliable recommendation conclusion.

4. The study materials and methods

The object of our study is the process to form a recommendation conclusion regarding the choice of a profession by a teenager based on the evaluation of the results of completing tasks in a computer multilevel professionally-oriented game.

The recommendation conclusion regarding the choice of a profession is formed during the electronic assessment of interest and special abilities based on the evaluation of the results of completing tasks in a computer multilevel professionally-oriented game, shown in Fig. 1.

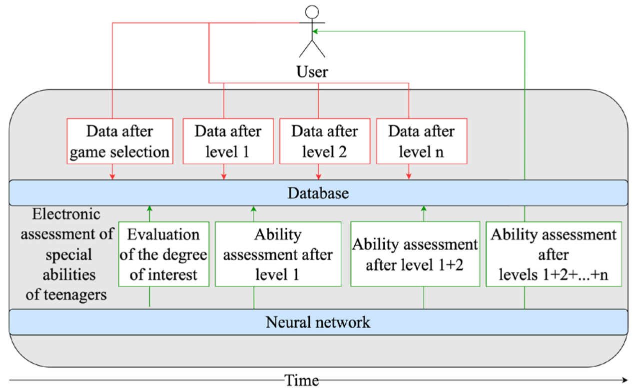


Fig. 1. Diagram of electronic assessment of interest and special abilities

In the scheme proposed in Fig. 1:

– the user of the system is a teenager who chooses a professionally-oriented game of interest to them for their professional self-identification and performs tasks of different levels of complexity;

– the user receives a recommendation on the choice of profession immediately after the game is finished;

– data on the results of the tasks are accumulated and stored in the database of the intelligent information and communication system, the distributed architecture of which is built and described in [22].

The system proposed in [22] has a microservice architecture with significant potential for expansion, is able to store copies of data in cloud storage and supports the possibility of asynchronous generation of the User's game results until the completion of all levels of the game.

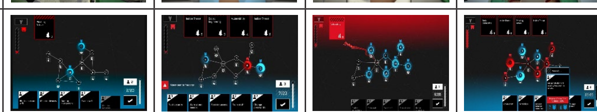
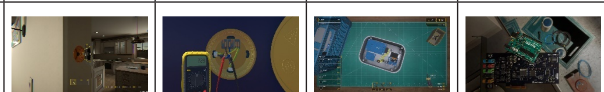
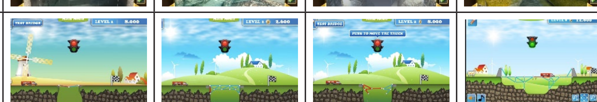
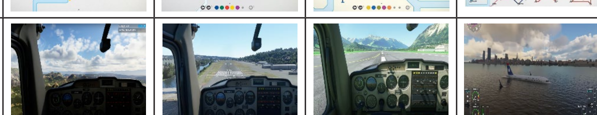
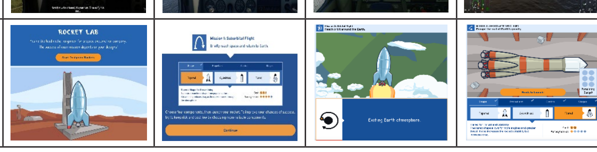
The main idea of this study is that, unlike [22], the recommendation conclusion is formed not by a neuro-fuzzy inference system, but by a pre-trained MLP based on the accumulated data on the results of the tasks of all levels of the professionally-oriented game.

For experiments, 4-level games were selected with the first level rating of "0" or "1". Moreover, "1" registers the expediency of further assessment, other levels are a source of data on "time" and "number of attempts", and the teenager is not limited to the number of attempts to assess the abilities to master any specialty.

Examples of game tasks that make it possible to assess the level of compliance of the teenager's special abilities with the personnel qualification requirements for the specialist profile are given in Table 1 and described in [18, 19].

Table 1

Fragment of the database of professionally oriented multi-level computer games

Game	Level 1	Level 2	Level 3	Level 4	Sector
Surgeon simulator					222 «Surgery»
Zero Threat					125 «Cybersecurity»
Electrician					141 «Electrical power engineering, electrical engineering and electromechanics»
Architect					191 «Architecture»
Bridge Architect					192 «Construction and civil engineering»
Bridge builder					192 «Construction and civil engineering»
Plumber game					194 «Hydrotechnical construction, water engineering and water technologies»
Journey 2050 game					201 «Agronomy»
Driver					274 «Road transport»
Subway constructor					273 «Rail transport»
Microsoft flight simulator					272 «Aviation transport»
Rocket Lab					134 «Aviation and rocket and space technology»

Basic assumptions:

– the indicators "time" and "number of attempts" for passing the level adequately reflect the teenager's abilities to perform operational activities and guarantee sufficient accuracy and efficiency of the MLP training process;

– specialists perform tasks in advance according to different scenarios;

– the results of task performance by specialists are considered a reference and are used to normalize the data, on the basis of which a fuzzy recommendation conclusion is formed regarding the choice of a future profession;

– the adequacy of the choice of a professionally oriented game for assessing the level of compliance of the user's special abilities with the personnel qualification requirements for the profile of a specialist of the individual is guaranteed by experts.

The simplifications adopted in the work:

– the measure of interest is considered a constant value and is determined according to [18];

– the assessment of the teenager's readiness to acquire certain competencies is guaranteed by experts.

To ensure the ability of MLP to perform the categorization task, it is necessary to perform:

1. Preliminary information collection.

2. Training of the neural network model.

3. Experimental verification of the ability of the neural network to form a reliable recommendation conclusion.

In the first stage, the test group of adolescents performs tasks of computer games of professional orientation, and experts collect their results and provide a recommendation conclusion. The data set used for MLP training was formed from the game results (Table 1) of students at pre-university training courses of the Kyiv National University of Construction and Architecture who clearly determined the choice of profession. When solving each game task, the "time to complete levels" and "number of attempts" were recorded.

After each game session, experts analyzed the results of the adolescents' game, and each attempt, based on expert experience, was assigned to one of the classes: $\overline{R}(-1)$, $P(0)$, or $R(1)$. These results, labeled by lecturers from the departments of professional education and information technologies at the Kyiv National University of Civil Engineering and Architecture, formed the ground truth, which was used for MLP training.

Table 2 gives a fragment of the sample data for MLP training, obtained when testing teenagers who performed tasks in the Rocket Lab game.

At the third stage, an experimental test of the ability of the trained MLP to provide a recommendation conclusion is carried out, based on the results of which the analysis and adjustment of the neural network work are subsequently performed.

Table 2

A fragment of the training data sample and an MLP testing example

N	MLP training data								Conclusion
	ν_N	θ_{n1}	τ_2	k_2	τ_3	k_3	τ_4	k_4	
1	1	0	0	0	0	0	0	0	–1
2	0.5	1	1.96	1	1.75	1	1.9	1	1
3	0.8	1	2.07	3	10	2	2.35	4	–1
4	0.8	1	20	1	2.67	4	3.16	6	–1
5	0.6	1	2.67	4	1.18	5	1.58	3	0
6	0.3	1	1.25	5	1.91	1	1.97	1	1
7	0.3	1	2.61	3	2.9	9	3.33	10	–1
8	0.1	1	1.71	3	1.6	4	4	1	0
9	0.9	1	2.73	6	1.4	6	1.62	6	0
10	1	1	2.22	1	2.22	1	1.28	3	1
11	0.7	1	1.28	3	1.6	4	1.28	3	1
12	0.7	1	1.4	6	1.9	4	2.22	1	1
13	0.5	1	6	6	2.73	6	2.73	6	–1
14	0.5	1	1.72	1	1.36	3	1.36	3	1
15	0.4	1	1.76	1	1.67	5	1.82	2	0
16	0.8	1	1.75	1	26.67	40	2.5	10	–1
17	0.4	1	3	3	2.5	2	1.82	5	0
18	1	1	3	3	2.5	5	3	3	–1
19	0.2	1	1.29	4	1.82	1	1.87	1	1
20	0.8	1	1.25	5	2.86	1	1.4	6	0
MLP test example									
1	0.5	1	2.67	2	6.12	4	5.57	2	0

The data collection was carried out on a sample of 100 adolescents aged 15–16 years, who performed the tasks of the games given in Table 2 of their choice. These data are not enough to train a neural network with an unsupervised learning, but they are enough to conduct an experimental test of the correspondence between the MLP conclusion and the expert conclusion.

5. Results of modeling the recommendation conclusion generation process based on MLP

5. 1. Formalization of the conclusion formation process

To form a conclusion on the appropriateness of choosing a profession based on estimates of the degree of interest, time, and number of attempts used in performing tasks by a professionally oriented computer neural network, the task is formulated as a categorization task, where the MLP receives as input:

– estimates of the degree of interest and readiness for learning;

– time and number of attempts to complete the game level.

To form a recommendation conclusion on choosing a profession based on the categorization of the result of the corresponding game, it is proposed to use formula (1):

$$Y = f\left(\theta_N + \nu_N\right), \quad (1)$$

where $Y=\{Y_1, Y_2, Y_3\}$ – fuzzy linguistic inference: possible ($P(0)$); recommended ($R(1)$); not recommended ($\overline{R}(-1)$), which the user receives after the end of the game and sees in real time; the coordinates of the vector Y are the measures of belonging of the game results to one of three classes; N – the number of game levels; θ_N and ν_N – assessments of abilities to professional activity reproduced in the game, and measures of interest and to the profession.

To assess the interest and special abilities of a teenager based on the results of a multi-level professionally-oriented computer game, it is proposed to use mathematical model (2):

$$\theta_N = \theta_{n1} + \sum_{n=2}^{N} \min\left(\frac{C_{tn}}{\tau_n}, 1\right) + \sum_{n=2}^{N} \frac{1}{k_n} \rightarrow \max, \quad (2)$$

where θ_N – assessment of abilities to perform operational activities; $\theta_1=\{0, 1\}$ – assessment of readiness for learning; $n\left(n=\overline{1,N}\right)$ – level of N-level game; C_{tn} – constant determined by the time of completion of the task of the n-th level of the game by a specialist; τ_n – time spent by the user on passing the n-th level of the game; 1 – constant, which means achieving the result by the specialist on the first attempt; k_n – number of attempts spent by the user to pass the n-th level of the game.

With such a statement of the problem, the assessment of the user's abilities is formed as the sum of the ratios of the results of the game tasks performed by the user and the specialist:

– $\sum_{n=2}^{N} \min\left(\frac{C_{tn}}{\tau_n}, 1\right)$ – by the indicator "time";

– $\sum_{n=2}^{N} \frac{1}{k_n}$ – by the indicator "number of attempts".

In this work, N=4 (Table 1) and MLP receives as input an 8-dimensional vector, which is formed by the results of completing tasks of a 4-level game.

5. 2. Neural network design

In this paper, we investigated MLP with one hidden layer of 48 nodes and MLP with successive layers of 32 and 16 nodes. In this case, MLP with successive layers of 32 and 16 nodes showed better categorization results in terms of accuracy (Fig. 2, *a*) and loss value (Fig. 2, *b*) compared to MLP with 1 hidden layer of 48 nodes.

In addition, the use of a two-layer architecture provides the neural network with the following advantages:

– step-by-step feature extraction: each layer of the neural network can gradually abstract features from the input data and by overlapping layers, the model builds complex functions step by step, revealing nonlinear relationships;

– flexibility for deeper models: the proposed structure makes it possible to increase the depth of the model, improving the learning of more complex relationships;

– in this format, it is easier to add layers or change their sizes.

Thus, the architecture of the MLP model with two consecutive hidden layers of 32 and 16 nodes is better suited for further research than the architecture with one hidden layer of 48 nodes.

The design of the neural network, which is proposed to be used to form a recommendation conclusion regarding the choice of a specialty based on the results of a 4-level computer game of professional orientation (Fig. 3):

1. Input layer: 8 input neurons to represent the input data in the form of an 8-dimensional vector. The coordinates of the input vector are the estimates of the degree of interest and the level of readiness (the result of the survey), as well as the time and number of attempts to complete each of the three levels of tasks of different complexity.

2. Hidden layers: two layers with 32 and 16 nodes (48 in total).

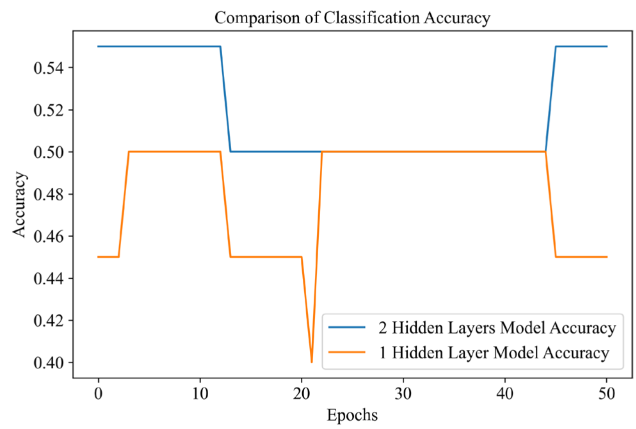
3. Output layer: consists of 3 neurons for the data classes $\overline{R}(-1)$, $P(0)$, and $R(1)$, which correspond to the conclusions "not recommended", "possible", and "recommended". To transform the MLP output data into a probability vector and create a probability distribution between the data classes, the Softmax activation function was used [24].

Neural network configuration:

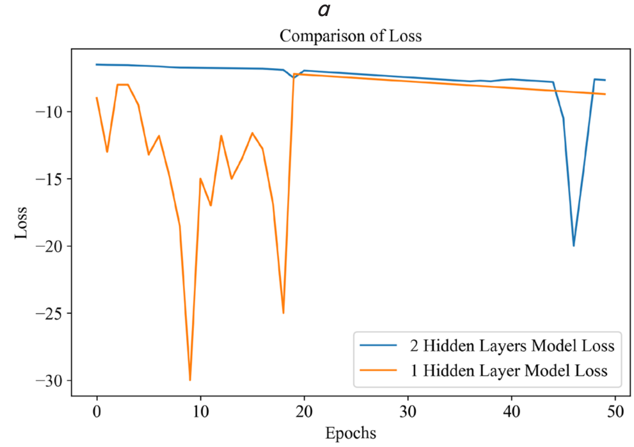
– categorical cross-entropy was used as a loss function to estimate the probability of the conclusion belonging to each class [25];

– ReLU was used as an activation function to introduce nonlinearity of the output neurons [23];

– Adam optimizer was used to adjust the MLP learning rate, which allows it to work well in a wide range of tasks and architectures [26].



a



b

Fig. 2. Comparison of categorization ability of MLP with two and one hidden layers

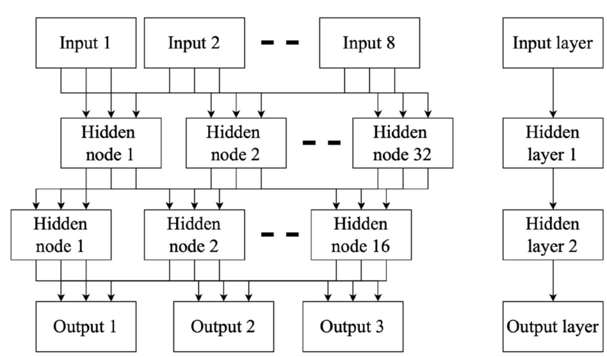


Fig. 3. Neural network design

Such training based on categorized data and a loss function combines the advantages of supervised learning and adaptation to specific tasks.

5. 3. Experimental verification of the MLP ability to form a reliable recommendation conclusion

The selection of games for assessing abilities, which are to varying degrees necessary for acquiring skills and abilities that meet the requirements for the specialist profile, taking into account the qualification requirements for graduates, is entrusted to experts.

To test MLP, the user played the Rocket Lab game, on the basis of which the neural network was trained.

After submitting to the MLP input (Fig. 3) the test results of the Rocket Lab tasks (Table 2), which were used to check the operation of the neural network, the output was an array [0.3526, 0.3933, 0.2541]. These initial data are an estimate of the probabilities of the recommendation conclusion belonging to each of the initial classes $\bar{R}(-1)$, $P(0)$, $R(1)$. The neural network showed the greatest value at output 2 (Y_2=0.3933), which provides grounds for substantiating the conclusion of "possibly" the class $P(0)$.

The cumulative scores of the Rocket Lab game results, calculated using formula (2), allow the expert to evaluate the results of completing tasks at each level (Table 3) and monitor (analyze and correct) the work of MLP.

Table 3

Fragment of the cumulative score of the Rocket Lab game results

N	$\nu_1=\nu_N$	θ_1	θ_2	θ_3	θ_4	$\theta_N+\nu_N$	Expert opinion
Specialist's result							
0	1	1	3	5	7	8	Recommended
User result							
1	1	0	–	–	–	1	Not recommended
2	0.5	1	3	5	7	7.5	Recommended
3	0.8	1	2.3	3	4.1	4.9	Not recommended
4	0.8	1	2.1	3.1	3.9	4.7	Not recommended
5	0.6	1	2	3.9	5.5	6.1	Possible
6	0.3	1	2.8	4.8	6.8	7.1	Recommended
7	0.3	1	2.1	2.9	3.6	3.9	Not recommended
8	0.1	1	2.5	4	5.5	5.6	Possible
9	0.9	1	1.9	3.5	4.9	5.8	Recommended
10	1	1	2.9	4.8	6.7	7.7	Recommended
11	0.7	1	2.9	4.4	6.3	7	Possible
12	0.7	1	2.6	3.9	5.8	6.5	Not recommended
13	0.5	1	1.5	2.4	3.3	3.8	Recommended
14	0.5	1	3	4.8	6.6	7.1	Possible
15	0.4	1	3	4.4	6	6.4	Not recommended
16	0.8	1	3	3.1	4	4.8	Recommended
17	0.4	1	2	3.3	4.6	5	Possible
18	1	1	2	3	4	5	Not recommended
19	0.2	1	2.8	4.8	6.8	7	Recommended
20	0.8	1	2.8	4.5	6.1	6.9	Possible

6. Discussion of results related to the formation of a recommendation conclusion based on MLP

The proposed approach to the formation of a recommendation conclusion on the feasibility of choosing a profession by a teenager is based on the use of existing professionally-oriented computer games. Unlike [12, 14], which considered the gamification of the educational process, this work is aimed at gamification of the career guidance process before the start of professional skills training. This approach makes it possible to identify natural abilities, rather than evaluate the learning outcome.

In addition, providing adolescents with the opportunity to choose games of different professional orientations helps them make a more informed choice of the profession from a set of alternatives, unlike [8], which offers an assessment of abilities to perform activities in one area. without unnecessary pressure from interested parties and the risk of human error.

For an expert assessment of the special abilities of a teenager, it is proposed to use mathematical model (2), which makes it possible to normalize the assessment of special abilities not only by the factor "time", as in [19], but also by the factor "the number of attempts". This makes it possible to eliminate the problem of assessment when guessing the correct strategy due to the rapid use of a large number of attempts. The weakness of the ability assessment is the assessment of the degree of interest in professional activity and the level of readiness for learning since it does not take into account the dependence of interest on the success of task performance and requires the involvement of career consultants. In addition, it remains outside the scope of modeling the impact of the nature of errors on the reliability of the recommendation conclusion.

The assessment of a teenager's ability to perform a certain activity relies on MLP. The design of the neural network used to form a recommendation conclusion based on the results of a 4-level computer game of professional orientation is shown in Fig. 3. However, the generalization of mathematical model (2) to any number of levels adds the ability to assess the user's abilities for various professional activities using a single tool.

The proposed neural network generates a recommendation conclusion based on the rules that are formed during its training. This makes it possible to scale the number of levels in a computer game without involving large human resources since when the game levels increase, it is enough to expand the data sample and retrain the existing model. Such a solution provides an opportunity to solve the problem of changing game levels and, unlike [19, 22], requires less effort when adjusting the rules in the event of a change in the number of game levels.

The diversity of data obtained when forming the sample for training the neural network (Table 2) can be explained by the different skills of the adolescents who participated in the experiment and different strategies for completing the games. Such variability cannot be predicted, therefore the use of MLP is justified by the fact that this neural network can detect nonlinear relationships.

The choice of a two-layer MLP architecture is justified by the better ability to classify by accuracy and loss value, as evidenced by Fig. 2. In addition, the proposed design makes it possible to increase the depth of the neural network, improving the learning of more complex relationships between various factors affecting the categorization result.

The conclusion about the expediency of choosing MLP, made on the basis of the results of the study reported in [22], is confirmed by the results of testing, as shown in the example (Table 2) when MLP provided a recommendation conclusion, which was confirmed by the expert.

However:

– when solving the categorization problem, the data of the array [0.3526, 0.3933, 0.2541] are close to each other, which may indicate doubts about the model;

– the initial interest in the specialty is low, but the user confidently confirms their readiness to study;

– the indicators of the last level deviate too much from 0 and show deviations with different signs, which means that it is possible to spend more time when choosing a strategy while using a smaller number of attempts.

In such cases, the conclusion of the neural network may be questioned. It is for the analysis of such cases that the cumulative estimates of the intermediate game results, calculated by formula (2), and the MLP conclusions are accumulated in the PostgreSQL professional abilities assessment system described in [22]. Expert analysis of the stored data will allow one to find out where the MLP overestimates or underestimates the results of the teenager's game and will provide an opportunity to improve the neural network since the expert-corrected conclusion can be added to the training sample.

Currently, the available statistical data is not enough to fully use MLP as a career consultant. But this neural network can be used under a test mode, as its assistant. Correct conclusions of MLP can improve the work of the consultant, because it can detect nonlinear dependences between time, number of attempts, and professional suitability. But MLP can also be wrong, so the primary task of its improvement is to adjust and control the process of training the neural network.

Eliminating the limitation of the training sample filling with different game scenarios could significantly improve the categorization results but requires additional data collection at schools, by providing adolescents with the opportunity to perform tasks of computer professionally-oriented games under the supervision of experts.

After that, the neural network can be integrated into school career guidance programs via an online platform, where:

– adolescents will be able to independently use computer games for professional self-identification;

– experts will be able to provide continuous feedback to improve the model.

To assess the results of each level of task performance, which is necessary for analyzing and adjusting MLP, experts need cumulative assessments of the results of the game played under different scenarios. The data format shown in Table 3 allows for expert assessment and comparison with the results of MLP.

At this stage of the work, involving experts and specialists to analyze cumulative assessments and understand the impact of various input data on managing the training process can be considered a limitation of MLP. However, further training of the neural network on a training sample of sufficient volume will provide an opportunity to ensure sufficient reliability of the recommendation conclusions for implementation in the system of career guidance support for adolescents.

7. Conclusions

1. To formalize the process of generating a conclusion on the appropriateness of choosing a profession, it is proposed to use a mathematical model, according to which:

– the recommendation conclusion is categorized according to the assessments of abilities and the degree of interest in the professional activity reproduced in the computer game;

– the assessment of the abilities to perform operational activities is determined by the time and number of attempts spent on completing the game tasks.

The proposed mathematical model also provides experts with the opportunity to evaluate the results of each level of the game and control the training of a multilayer perceptron.

2. The design of a multilayer perceptron with successive layers of 32 and 16 nodes has been proposed, capable of integrating with existing 4-level professionally-oriented computer games. However, the mathematical model, generalized to any number of levels, makes it possible to scale the number of levels in a computer game without involving large human resources, using one tool.

3. Experimental verification of the ability of the proposed multilayer perceptron to generate a reliable recommendation conclusion showed the possibility of its implementation in the systems of career guidance support for adolescents, provided that it is further trained on a training sample of sufficient volume. In this case, it is necessary to ensure continuous expert control over the neural network to correct possible errors and increase the reliability of recommendation conclusions.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study, as well as the results reported in this paper.

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Data availability

All data are available, either in numerical or graphical form, in the main text of the manuscript.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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