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GAMIFICATION IN BUSINESS LOGISTICS TRAINING THROUGH EVOLUTIONARY ALGORITHMS

Maria Vodenicharova[1], Angel Marchev, Jr[2]
e-mail: mvodenicharova@unwe.bg
e-mail: angel.marchev@unwe.bg

Abstract

Developing multifaceted contemporary individuals implies that they have to be constructed as one whole system, as well as provide for their creative realization. In order to improve the training of university students, innovative models for conducting lectures and seminars should be implemented. The change in curricula should meet the social requirements of the modern world and technologies used by students. Implementing gamification in the business logistics training should aim at studying and establishing logistics knowledge and skills activities and processes. The games included in the curriculum should take into consideration the changes and not only identify the state and progress students make and to provide opportunities for making business decisions, they should be motivating and correcting, generating ideas and alternatives.

Gamification is the application of game-design elements in various systems which can be used in education. Within the education framework this can involve a number of game mechanisms. The possibilities to use these game-design mechanisms to facilitate training have become the object of increasingly more research and are ever so often included in practice. The report will focus on identifying how these game mechanisms can improve knowledge in business logistics and along with that strengthen efficiency and the provision of new opportunities for instructors. The paper presents an educational computer game for evolutionary algorithms (EA) which could be used in class as well as for distance learning. After the essence of the EAs is reviewed, the plot and mechanics of the game are described as well. Furthermore, a comprehensive study on the game balance is conducted to showcase the advantages of using the game as an educational tool.

Key words: gamification, training, business logistics, supply chains, evolutionary algorithm, multi-stage selection procedure

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[1] Assoc. Prof., PhD, Department of Logistics and Supply Chain, Faculty of Infrastructure Economics, University of National and World Economy

[2] Assoc. Prof., PhD, Department of Management, Faculty of Management and Administration, University of National and World Economy

Introduction

Teaching and learning are two interrelated aspects of the process of education, which has undergone an evolutionary process over the centuries. In scholastic education the most important element in the process of knowledge acquisition is the memory. The students repeat what they have learned so that they can reproduce it mechanically. During the Renaissance teachers' attention focused on the immediate contact with real facts, i.e. the focal point is on students' perception and ideas. At the beginning of this century the theory and practice of education determined activity as a precondition for efficacy and efficiency of the education activity. Attempts were made to overcome the passive perception of knowledge and attention was directed to the formation of an active individual who can learn to understand the meaning of knowledge through personal efforts.

Nowadays the development of teaching in the higher educational institutions in Bulgaria witnesses a steady trend in strengthening activity in education. Active education is a key issue in business logistics, which considers the cognitive process not only as a means to acquire knowledge but also as the most important source for the development of students. Logistics as a scientific management involves a number of activities and processes and facilitates the material flows. These flows are seen as integrated and include client service, demand forecast, inventory management, provision, communications, warehousing and storage, packaging, transportation, order processing etc. Although not all organisations explicitly implement all these logistics activities, each and every one of them concerns logistics management. After the 90ies of the last century market changes speeded up, relying on the more comprehensive recognition of logistics and its development.

The wide-spectrum applications of evolutionary algorithms in various business fields (e.g. logistics, manufacturing, hi-tech, business management, etc.) make them a vital part of any contemporary business/technical education. Having said that, it is essential to form the educational content within the context of the contemporary learner.

Today's learner watches and listens, perceives and learns incomparably more in a unit of time than ever before. But at the same time, today's learner needs guidance and persuasion as to what the important areas of knowledge in an intensively informative environment are. The educational process needs a stimulating teaching, which should arouse interest in the educational field.

It has been proven that the best method is educational gamification as today's students are part of a generation known as Millennials born after 1980, for whom digital technology, e.g. Internet, computer games, e-mail, mobile phones and chat are all intertwined in almost every activity of their daily lives. They are characterized as things with computers and technology. As a result, they are, and are often called, the Net Generation, the Gamer Generation, or the Digital

Natives, because they have learned to speak the digital language of computers, video games and the Internet. By the age of 21, the typical representative of the current young generation has played 10,000 hours of games.

The purpose of this report is to consider the implementation of gamification in business logistics training by presenting a classification of the business logistics games and applying a used in class as well as for distance learning. Based in essence of the EAs is plot and mechanics of the game, which are described as well.

Tasks of the research are:

- To consider gamification in business logistics training;
- To classify business logistics game;
- To presents an educational computer game for evolutionary algorithms (EA);
- To describe the plot and mechanics of the game;
- To study that the game balance is conducted to showcase the advantages of using the game as an educational tool;
- To present an algorithm of the game.

Application of gamification

Over the past years the gamification model has become one of the leading topics for discussion around the world. According to Groh, the notion "gamification" applies to the use of a game or desire to stimulate the involvement of a consumer (trainee) in a given activity (Groh, 2012, pp. 39-46).

Gamification uses computer games in applied program securitization aiming to attract trainees and improve their involvement in knowledge acquisition.

Gamification can be included in any type of training without even making it an informed decision. The process of introducing game elements in a given subject or degree course adds value to the training. In logistics this is possible in purchasing different products or for presenting individual systems, such as JIT and the push effect.

The main goal in gamification is to guarantee a continuous, measurable feedback for students, provide an opportunity to improve knowledge and, as a result, quick acquisition of all functional capabilities of the studied subject with gradual introduction in details. In gamification it is possible to gradually change and expand goals and tasks along with the acquisition of experience which guarantees improvement of the results while preserving the involvement of students.

The key characteristics of gamification are related to: *the dynamics which in practice* means the use of scenarios, which call for attention on the part of the trainers and a response on the spot; *the mechanics, which includes* using elements typical of computer games of the virtual awards, status, gifts etc. type; *aesthetics as a characteristic of gamification involves* making the general impression of a game which contributes to emotional involvement of trainees and *social*

interaction which can include a wide range of techniques providing interaction between the trainers, which is characteristic of games.

Broadly speaking using games as an element of the educational environment is part of the philosophy of active learning. Kohn (1997) assumes that in order to stimulate deeper understanding of the materials, students should be committed to what they are doing. Passman (2001), Applefield, Huber, Moallem (2000, pp. 35-46) describe the benefits of adopting a more constructivist teaching model. According to McKeachie (1994) students' active participation results in positive learning and achievement of better results. McKeachie explains that learning improves if students make decisions and then have to take responsibility for the consequences of each decision (Klassen, Willoughby, 2003).

Business universities have broadly adopted the use of games and simulations in their curricula. Faria (1998, pp. 295-309) writes that 97.5% of the accredited business schools use simulation games in the courses taught. Most of these games address marketing or strategic issues. Bodo (2002, pp. 207-216) describes the development of simulation in the selection of strategies, designed by students. It is common to apply innovative technologies in the games. For example, Doyle and Brown (2000, pp. 330-342) introduced a business strategy which uses electronic mail and video conferencing where five teams of students in Business Administration in Ireland, France and the USA participate. Also, guidelines for developing games were designed by Heineke & Meile (2000), who suggest that games can be effective through: guaranteeing the "aha" effect – i.e. the received insight should remain unknown while the game is still being played; students should be expected to generate data (rather than get them ready) in order to acquire deeper understanding; guaranteeing lower stress levels among students and using simple materials (Klassen, Willoughby, 2003).

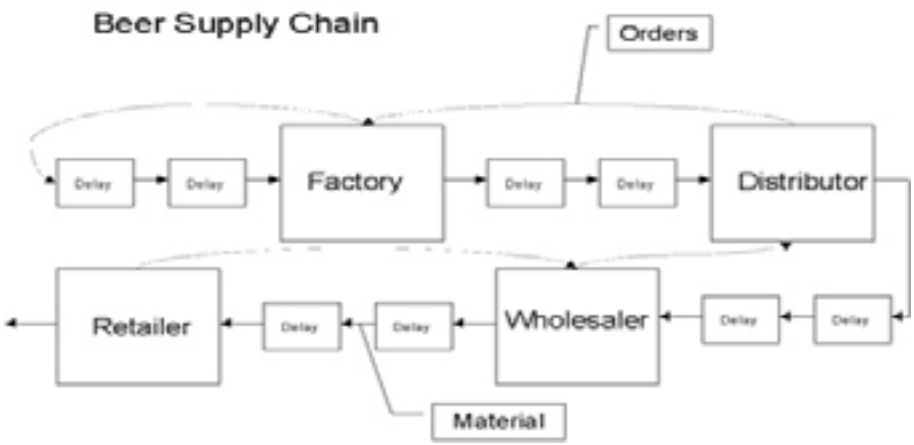
Gamification in business logistics training

Gamification in higher education performs complex functions which provide unity of the main activities and change in their relations and interdependence in order to achieve the full realization of the training and facilitate the development of the elements of the training activity and provide a transition to the practical implementation and the working environment.

Logistics training has become increasingly popular over the past years. This is evidenced by the new degree courses in logistics in different universities in the country. Currently, logistics training in Bulgaria is provided at UNWE – Sofia, The University of Economics in Varna, Todor Kableshkov University of Transport, The Naval Academy, The National Military University – Veliko Turnovo, the Georgi Rakovski Military Academy etc.

It can be stated that gamification in logistics training and chain management started with the creation of the beer game, which is very popular among both

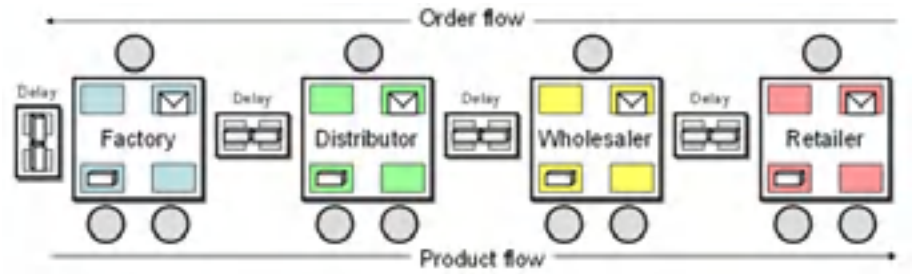
teachers and students. This is one of the most popular demonstrations in management created by John Stirman (1992, pp.40-44). In this game a retailer sells beer to end users and buys the beer from a wholesaler. The wholesaler sells the beer to the retailer but he orders it from the brewery where the beer is produced. The delivery chain is shown in the figure 1.



Source: Sterman (1992, pp. 40-44).

Figure 1: Beer supply chain

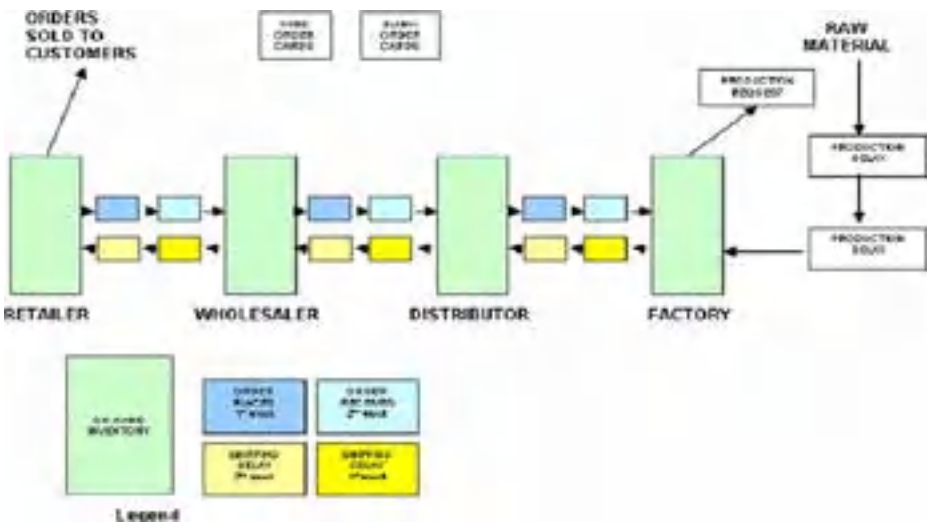
University logistics training is of paramount importance for the students' successful training and therefore their business career. It can be observed in their independent, conscious and creative learning and thinking. In the process of active logistics training and supply chain management the student analyses the task, its goal and its formulation which are related to inventory management and customer service. This activity is an important condition for acquiring long-lasting knowledge and skills in business logistics. Software products for project management or business processes, warehouse software products are an indispensable element of the logistics training.



Source: beergame.org (n.d.).

Figure 2: Logistics flows

The current stage in the development of logistics is the supply chain management – this is a complex systematic approach with a high degree of interaction and requires simultaneous consideration of a number of interrelations and strategic thinking. By adopting the entire supply chain concept, the participants represent all companies and organisations a given company works directly or indirectly through its suppliers and clients from the moment resources are produced to the point of product consumption. The researchers of these channels determine the members according to their participation in the different flows which are connected with the product, the right to ownership, payments, information, the promotion activities and the logistics flow (Stern, El-Ansary and Coughlan, 1996, pp. 8-22). The researchers of these channels determine the members according to their participation in the different flows, which are connected with the product, the right to ownership, payments, information, the promotion activities and the logistics flow. What is more, they try to involve all components which take part in the logistics flows irrespective of their contribution to the benefits for the end clients.



Source: Cox & Walker (2006).

Figure 3: Supply chain management

In logistics and supply chain management training elements of Gamification such as tests, simulations, actual case studies, reality interviews etc. and the implementation of specific games in business logistics would considerably improve the success in acquiring new knowledge.

Classification of business logistics games

The classification of games used in business logistics training can include the following types:

1/ Creative games

- role-playing games with intelligence, research and forecast plots in inventory management;
- designing logistics channels, centres etc.

The management of creative games is indirect. The instructor does not regulate the game activities of the students but manages through the realization of the structural elements of this type of game. Therefore, the analysis of the psychological structure of the creative game that the students recreate ("in the shop", 'the library", "at the station", 'in the supermarket", 'at the post office" and many others) is of significant methodological importance. An example of a game applied in logistics is the so called distribution game. It is designed in accordance with the globalization trends in supply chains. The players are the distributors and have to run a global network of suppliers and clients, each of them with its individual characteristics. The players have to manage products with high depreciation like electronics. The inventory management and the interpretation of the market development are of crucial importance to the players.

Another type of distribution game may involve the development of skills to control a small supply chain which is divided into two levels. The students have to monitor the quantity which is to be shipped by the manufacturer to the warehouse. Apart from that, it is important to monitor the number of shipments to different retailers. The goal of this game is to ensure that students deal effectively with the flow of goods to guarantee the customers' random demand in different locations. The students that generate the biggest net profit are the winners. If the shops do not have enough stock, they are not in a position to meet demand and suffer losses of income. These games reflect the problems related to ordering and distribution at different levels and distribution systems. The distribution systems typically have two levels of retention: a central warehouse and a retailer. The players have to monitor both levels and have to make decisions related to: when and how much to order from the supplier? When to transport the goods and how much to ship to each retailer? Clients purchase from retailers and the goal is to generate as much money as possible from these sales. One cannot sell something that is not available. Each retailer should be sufficiently stocked, but overstocking the system will result in higher expenditure. The following three decisions have to be made at every stage of the game:

1. How much to order from the supplier?
2. How much to send to retailer 1?
3. How much to send to retailer 2?

Recreating the activities and the relations in the business environment, the players should aim to demonstrate their own qualities and pattern of behavior. This demonstration is closely related to the development of self-awareness, self-evaluation and self-analysis. This is one of the specifics of logistics games, which turns game reality into a kind of self-education.

Students try to reproduce with greater accuracy the reality, i.e. conditionality gradually is replaced by the real specifics of the conditions and the objects used by players to create an imaginary situation.

Business logistics training uses other types of games related to order stimulation and warehouse arrangement.[3] Students try to reproduce with greater accuracy the reality, i.e. conditionality gradually is replaced by the real specifics of the conditions and the objects used by players to create an imaginary situation.

The leader of the game is aware of the structure of creative games and specifics of each structural element, which helps him guarantee maximum developing impact of the given game both in terms of the individual student and the team as a whole.

Business logistics training uses other types of games related to order stimulation and warehouse arrangement. This type of game is based on the idea of M. Amirhosseini from UPS Worldwide Logistics and aims to help to understand the challenges related to balancing work when clients' orders are selected gradually. In this game players start with the simplest method of selecting orders where one worker selects an order. An the beginning of the game the workers usually stand side by side. And at the end the orders are fulfilled in a sequence different from that at the beginning. In an actual warehouse this would create jobs down the supply chain to the packaging where orders can be separated.

2/ Games with rules

Didactic games. Didactic games can be used in education and include elements from the teaching content of individual subjects. As an independent game practice didactic games are intellectual and cognitive.

Didactic games are typical games where rules are observed and thus intellectual and cognitive tasks are solved. These games can be used as a training tool because they are closely related to the respective logistics subjects (transport, warehousing, inventory management, project management and quality management in logistics). JIT – Kanban is an example of such a game. The production system in this game is controlled with Kanban cards. This means that the quantity of products between each production stage is limited. Just a limited number of units are stored and a limited number of units are produced. Production through the Kanban system is an example of a pull system. The "Kanban" game focuses on the control of a working center where four products: A, B, C and D

[3] A demonstration of the effectiveness of bucket brigades.

are manufactured. To produce one of these products in this working center, the production line has to be fine-tuned at each stage of production. Switching from production of one product to production of another one requires almost the same materials needed for the production of one unit. Adding or removing employees changes the production capacity.

A similar game, designed by Peter Jackson – THE CUPS GAME (Jackson, 1996), illustrates the difference between pulling and pushing in production. It is also effective in demonstrating the advantages of small lot production. This game makes a very convincing argument for just-in-time production.

Source: Innovation World Cap (n.d.).

Figure 4: Logistics game with rules

Effective game in logistics training will help students understand concepts faster and remember lectures better. A game which is used for simulation of an inventory management system can be associated with the creation of an order for a given good on a monthly basis and the goal is to find the optimal size of the order with minimum expenditure. It describes the expenditure incurred to store the unsold items and the expenditure incurred when a certain item is sold out (Klassen, Willoughby, 2003).

Similar games have been designed to be used in inventory management through simulation of a sports goods retailer who has to arrange goods appropriately and the students decide when and how much to order every month for a period of one year.

The game tasks are intellectual, cognitive and help develop the brain activities needed to understand the content of the subject. The cognitive activity is stimulated and knowledge is acquired and improved.

Like creative games, didactic games have a psychological structure and being familiar with it helps determine the methodological devices to be used by the teacher to manage the game.

The content of didactic games has several essential characteristics:

- *Cognition*. It is determined by the fact that students have at their disposal a set of knowledge which they can use to play the game. This is why the didactic game consolidates and specifies the knowledge acquired in the training process.
- *Integrity*. Everything that the student has acquired through various activities, at different times is integrated in the game and this is of great importance to logistics training. Knowledge and skills are used in synergy. This is why didactic games have the role of an integrating unit with other subjects and different activities in the business logistics training.
- *Problem areas*. In the process of playing the game students find a new way to organize their knowledge, new analogy, new differentiation.

Students practice various in terms of specific content activities and operations related to incoming, internal and outgoing logistics. For example, in games related to inventory management, they develop skills concerning decisions about when and what quantity of a particular product to order. These games are designed to improve studying, inform students about the key concepts related to inventory management, give students the chance to test their intuition and to demonstrate how disappointing it is to make decisions in an environment with uncertainties.

The didactic game stands out with focus, motivation and stimulates overcoming difficulties. In this case "explicit" game rules are of particular importance since the willful regulation consists mostly in the skill to act in accordance with the recognized requirements and rules. A must in leading a didactic game is the consideration of the wording of the game rule because the mechanism of willful activity requires text instructions. While solving a cognitive task the student carries out on multiple occasions the structure of the willful activity, i.e.:

- Achieving the goal;
- Outlining the way to be carried out;
- Selecting adequate actions;
- Overcoming difficulties.

The conation is facilitated by the game situation and game motivation.

The control and evaluation require the point of view which should be related to the rights of the didactic game. Therefore, following the rules, the students who play the game learn to apply criteria for evaluation and self-assessment.

Didactic games activate intellectual experiences – satisfaction from solving a cognitive task, from the chance to apply knowledge in new situations, from dealing with an issue that has arisen. Equally important are the experiences and feelings involved in the group participation in the game activities and the satisfaction from achieving the common goal.

The didactic game contributes considerably to the better application of the didactic attitude in the learning process which finds expression in the following:

- uniformity between the internal positions of the teacher in the teaching process and of the student in the learning process;
- uniformity between the structure of knowledge the student should have and the learning methods;
- uniformity between the structures of teaching and learning;
- uniformity between the knowledge that the student has acquired in the organized process of learning and the knowledge he will acquire during the self-study process.

If we compare the structure of the learning situation with the structure of the situation in the didactic game, we will see that they match. The game is a way to confirm and complicate the learning task in terms of the specific game goal – in this case it is a teaching method.

Therefore, the inclusion of a didactic game in the learning activity, on the one hand is structurally justified and on the other, it is in direct interdependence with the program tasks in each subject.

Evolutionary algorithms in brief

Evolutionary algorithms fall in the class of meta-heuristic numerical estimation methods. They are population-based methods, inspired by biological evolution mechanisms, such as reproduction, mutation, recombination and selection. Candidate solutions to the numerical problem are considered as individuals in the population, and the fitness function determines the quality of the solutions. The evolution of the population is then made after repeated application of the above operators.

Evolutionary algorithms often solve well numerical approximations of all kinds of problems, since they make no assumptions about the space of solutions. In most real-world applications of evolutionary algorithms, computational complexity is the limiting factor. However, a simple evolutionary algorithm can often solve complex problems, i.e. there is no direct relationship between the complexity of the algorithm and the complexity of the problem. Most often, applications are in the areas of operations research, numerical optimization, automatic control, and in general – machine learning.

A possible approach for automatized synthesis of mathematical descriptions is the multi-stage selection procedure (MSSP). This approach is similar to the directed selection in genetics and biology.

In its most general case, the multi-stage selection operates with mathematical description of a possible solution to a given problem in the form of an equation or functional dependence, ordered set of values of significant variables, logically testable statements, etc.

The main feature of MSSP is that a large number of perspective hypotheses are "fighting for survival" and evaluated in a highly automatized procedure, which selects the best out of many more. Various criteria for selection could be used to synthesize solutions with prerequisite features.

Evaluations of parameters and the selection of the significant factors is performed in the course of the procedure. The most suitable mathematical descriptions (MDs) are selected for the next stage etc. The biggest drawback of MSSP is the high requirements for computational power.

In general, MSSP includes several phases (figure 5):

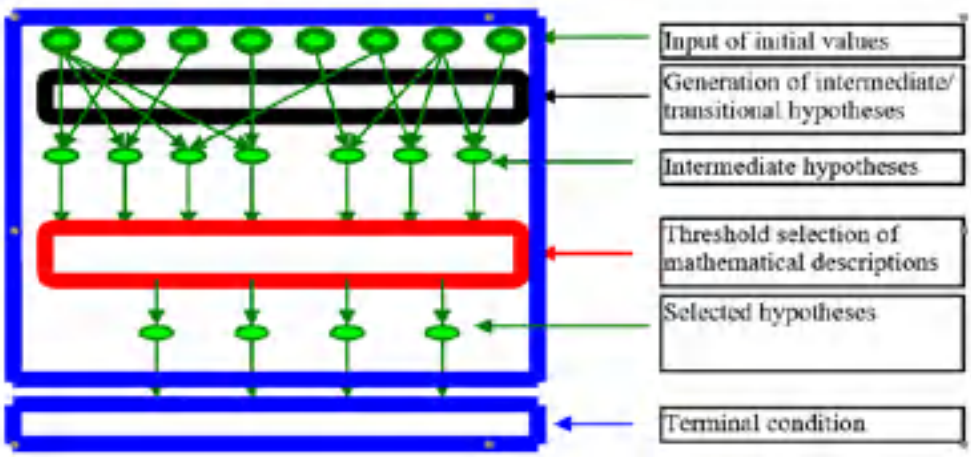
1) Input of initial mathematical descriptions (MD). Should the research need it, the mathematical descriptions may be divided in subsets for training, validation and testing.

2) Generation of offspring of competing MDs. Each generated MD is considered as a possible solution to the problem while at the same time it competes for existence with all the rest. It is very important that after each stage not only one best solution/MD is selected but a set of several best solutions. This is called the principle of inconclusive decision.

3) Threshold selection of a set of "good" MDs based on a preset criterion. The selected MDs after each stage of the procedure are used for generating a new population of MDs, out of which in turn will be selected a new set of "good" MDs and so on. (Principle of inconclusive decision). The criterion for selection may be varied from stage to stage.

4) Generation of a new offspring set of MDs and/or random mutation of the generation. The features of the mathematical description (MD) of the final solution are initially unknown as they are emerging during several stages of selection. At every stage new intermediate/transitional MDs are generated, which implicitly almost guarantee more complex combinations of the initial MDs.

5) Terminal condition – the MSSP stops when certain conditions are met as for example given rate of conversion, precision of estimation etc. For the purpose of shortening computation time alternatively may be defined conditions for requisite maximum variety, maximum correlation, maximum number of stages, etc.



Source: Compiled by the authors

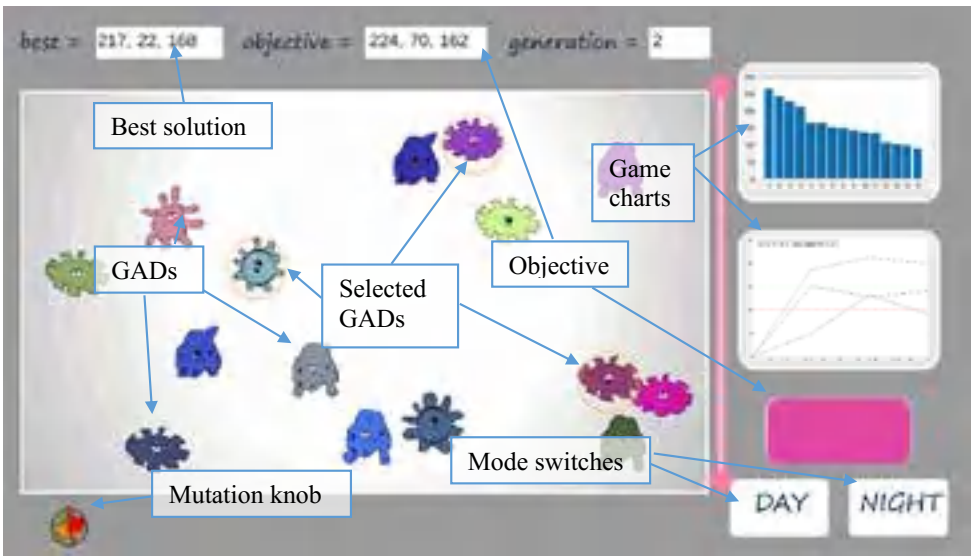
Figure 5: General scheme of a multi-stage selection procedure

Making of GAD Selection

GAD Selection was created as an educational game, exemplifying the main concepts of the evolutionary algorithms. The game was created by Angel Marchev (Story/Gameplay), Mihaela Komitova (2D Art), and Martin Doychev (Game Development) in Unity3d.

The plot is simplistic: the player has to breed a specific kind of genetic alien devices (GADs) through the process of multi-stage directed selection. There is an objective feature state (color) which has to be achieved in at least one of the GADs.

The players select those GADs whose genes could be used to achieve a GAD closer to the objective in the next generation of GADs. The non-selected GADs are disposed, and a new generation of GADs are bred by cross mating the selected ones. Sometimes there is a need to use the random mutation as a means to move the selection in a new direction. Breeding a GAD close enough to the objective for less than 10 generations and the player wins.



Source: Compiled by the authors

Figure 6: Interface of the main screen of Gad Selection

Methodology

The game introduces the players to the evolutionary algorithms. Playing as the de-facto algorithm, they learn the most important phases and concepts of one such algorithm – the Multi-Stage Selection Procedure.

The game could be used in a number of ways, according to the teaching style of the particular course. Here is a suggested a method of teaching:

1. Introduction of the game – the educator clarifies the game goal, rules and controls, by demonstrating the game.
2. Collective play – at least once the game should be played with the whole class taking tactical advice from multiple people. At this phase the students are both being activated for the game and start to think of personal strategies. Also, this is the correct moment for the educator to explain the introductory principles of evolutionary algorithms – selection reproduction, recombination.
3. Advanced collective play – still playing the game collectively (probably starting anew) it is time for the educator to explain the more advanced concepts of local minima trap and mutation for escaping it. By this time the concept of requisite variety would be surfacing in the students' rationale, so probably it would be an adequate time to explain it as well.
4. Individual play – time for the students to develop strategies on their own by playing several times the game (on computers of mobile devices). A competition among students is a must. Finishing with a briefing.

5. Homework/Distance play – the game is suitable for distance play (being available on URL) but furthermore it is suitable for homework assignments. One such assignment could be to reproduce the algorithm in a favorite programing language. A next assignment may be to program an algorithm to solve the game autonomously. And a next one would be to simulate this algorithm for many game scenarios.

Algorithm of the game

1. Generate random GADs, in the form of 3-element random vectors, where each element represents a color value, uniformly distributed between 0 and 255.

$$X_i = \langle x_{i1}, x_{i2}, x_{i3} \rangle \wedge x \square U(0...255)$$

2. Generate an objective, a 3-element random vector, where each element represents a color value, uniformly distributed between 0 and 255.

$$Y = \langle y_1, y_2, y_3 \rangle \wedge y \square U(0...255)$$

3. Begin a new generation.

$$G = \begin{cases} 0, G \in \varnothing \\ G+1, G \in \square \end{cases}$$

4. Player selects subset of GADs to be used for the reproduction of the next generation.

$$X_i \in \Omega$$

5. Kill non-selected GADs

$$X_{\notin \Omega} = \varnothing$$

6. Calculate Reverse Euclidean distance between each selected GAD and the objective.

$$E_{X \in \Omega} = 300 - \sqrt{\sum_{i=1}^{3} (x_i - y_i)^2}$$

7. Generation of new GADs by full pairwise mean-coupling of the selected GADs.

$$X_{G+1} = \frac{(X_i + X_j)}{2}$$

8. Mutation of all current GADs, if the player chooses to do it.

$$X_i = X_i + W_i \wedge W_i \square N(0,15)$$

9. Capping, if case any of the values after generation and mutation is less than 0 or more than 255.

$$x_i = \begin{cases} 0, x_i < 0 \\ x_i \\ 255, x_i > 255 \end{cases}$$

10. Determine best candidate solution GAD, as the one with minimal Euclidean distance.

$$X^* = X_{E_{\max}}$$

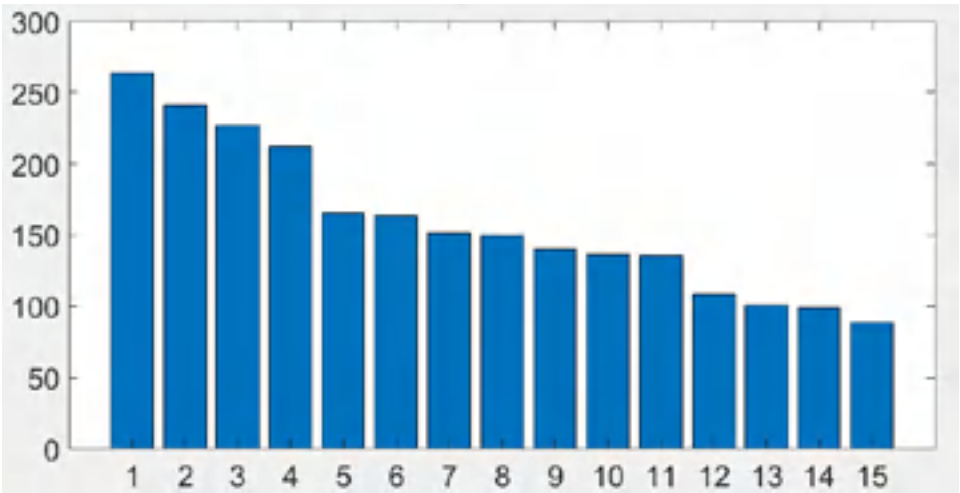
11. Check if terminal conditions are met:
- if the best GAD is approximately equivalent to the objective, then set win game state to 1;
- else if 10 generations have passed, then win game state to 0;
- else, go to step 3 (begin a new generation).

$$S = \begin{cases} 1, \left|x_1^* - y_1\right| \wedge \left|x_2^* - y_2\right| \wedge \left|x_3^* - y_3\right| \approx 0 \wedge G < 10 \\ 0, \left|x_1^* - y_1\right| \wedge \left|x_2^* - y_2\right| \wedge \left|x_3^* - y_3\right| \neq 0 \wedge G = 10 \\ \varnothing, \left|x_1^* - y_1\right| \wedge \left|x_2^* - y_2\right| \wedge \left|x_3^* - y_3\right| \neq 0 \wedge G < 10 \end{cases}$$

Simulation testing of GAD Selection

In order to balance the game a simulation study is done. The simulation closely follows the above-mentioned algorithm, but in step 4 and step 8 autonomous rules are implemented instead of a player's decision.

In step 4 the best 5 (out of possible 15) solutions are selected by ordering them on reverse Euclidean distance (figure 7).



Source: Compiled by the authors

Figure 7: Selected candidate solutions (ordered by reverse Euclidean distance)

Regarding step 8 (choice to use mutation) the implemented rule states that if there is no change in the value of the best solution from the generation and the game is not solved, then use mutation (see example in figure 8).

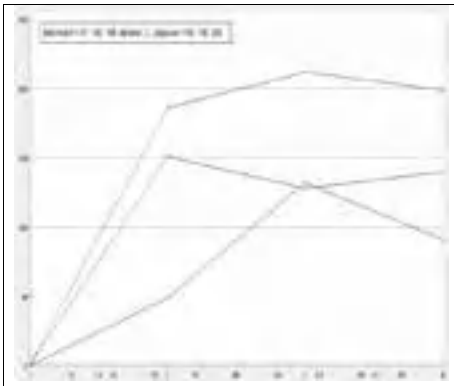


Figure 8a: A solved game in 3 generations

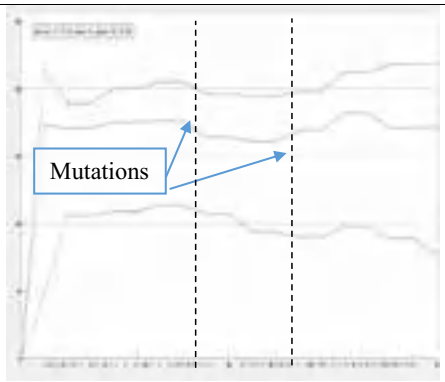
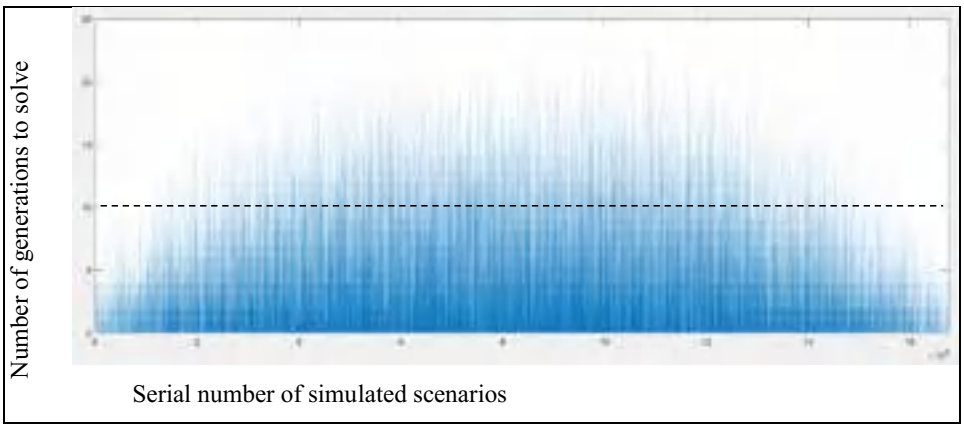


Figure 8b: A game with mutations

The simulation study is run for all possible scenarios (combinations of colors), altogether 256 x 256 x 256 = 16777216, using the prescribed autonomous strategy 10 times per scenario. The results are visualized on figure 9.



Source: Compiled by the authors

Figure 9: Simulation results

The immediate conclusions are:

- Spotty solvability. Since the recorded simulations perambulate all possible scenarios, figure 9 in effect renders the solution space (response surface) of the game. Even though the figure compresses four dimensions (red, green, blue, number of generations) in two dimensions be reordering of the results, it is obvious that there is high variability. The response surface is not smooth, and this means small changes in the spot of the scenario dramatically changes the possible outcome.
- Central tendency. The serial numbers of the scenarios are non-random, so the visible central tendency is a fact. This is probably due to the boundary conditions of colors (e.g. [0,0,255] is pure blue).
- Relatively hard general solvability. Simulating only about 58.5% of the scenarios turned out to be solvable within 10 generations of play.

Conclusion

Games broaden students' knowledge, enrich their terminology, facilitate the process of generalizing, drawing conclusions and identifying patterns. They help develop a set of mental, practical and physical activities and operations. The difficult situations, typical of games, develop actively the intellectual capacity of students and facilitate their participation in the difficult cases in business logistics. Students' emotional satisfaction is achieved through their participation in different games and contributes to providing a favorable "psychological

climate", which is identified during the teaching process thanks to the mechanism for transmitting emotional states.

The introduction of games in the logistics curriculum can help the development of general mental capacity and components of creativity as a universal ability. It can be claimed that games in education contribute to the acquisition, enhancement, broadening and generalization of knowledge; improve the capacity of students to act and think. The complex system of tasks and variants, of rules and content leads to the emergence of new interesting game situations, in which students become an active subject of the game structures and make efforts to control them and exercise self-control.

Education has always been a factor for social changes. Today, more than ever, it has to contribute to the more dynamic nature of the social processes because of the change in the economic and social life. If education is to be improved, its mechanisms have to be enhanced, a strategy should be built in order to improve its efficiency and to facilitate the solution of its problems. The contradictions between the contemporary requirements and the state of the system must be overcome in order to make education a means for life realization. Nowadays education should be considered broadly, which will make it possible to conduct future educational reforms and to shape both their content and their methodology. Education should not ignore any of the aspects of personal potential capacity: memory, motivation, aesthetic quality, communication. Special attention should be paid to games in the logistics teaching process at universities.

The introduction of games in higher education is based on a number of factors. First, games are of great importance for the formation of a multifaceted and broadly developed personality. Second, the connection between games and subjects included in the curriculum of business logistics: inventory management, logistics systems, warehouse and shipping systems, management of logistics projects, spiral nature of acquiring business experience and the development of the personality; difficulties as the ground for improved efficiency. Third, the role of games for conducting the transition and connection between training and business and the practical nature of the training process and demonstration of creativity by students; problems in teaching situations; uniformity between collective and individual forms of activity.

Didactic games include different approaches for knowledge acquisition: inherent to the content of the subject /logical schemes for acquiring and differentiating the essential principles of subjects and phenomena so that all aspects can be considered/; main and secondary, reproducing the logic of the solution of the tasks. In the structure of didactic games as a form of education rational approaches are connected with the functions that a student has to carry out in order to solve the task. These do not necessarily coincide with the rules of

the game but depend on their sequence and refer to the general thinking strategy in the process of solving the task. The didactic game as a method for knowledge acquisition aims to achieve an independent broadening of knowledge and the ensuing changes in new situations which call for the realization of the way of acting and thinking, stronger self-deduction and self-control in its implementation. This is typical of the process of overcoming intellectual difficulties and for the positive attitude to the approach to solving as a mechanism which turns the set approaches into a sustainable personal training.

The advantages of gamification in business logistics training are:

1. the type of game – this is a game which recreates the logistics system with the dynamic problems of a real system.

2. implementation of a simulation package to design a real scenario with the possibility to consider all factors (logistic processes, people skills etc.).

3. the likely applications since the game can be used not only as a training means but also as an instrument to assess the managerial skills of a potential manager to face the real and dynamic logistics problems.

Originality/value

This study reveals for the first time the Gamification in logistics training in Bulgaria and provides directions for development. This study shows that game balance is conducted to showcase the advantages of using the game as an educational tool.

Sponsoring research

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