Research on Configuration Framework of Simulation Rules Based on Existing Simulation Teaching Platform

Wenqiang Li, Juanqiong Gou, Shuyao He, Zhe Wang

Research on Configuration Framework of Simulation Rules Based on Existing Simulation Teaching Platform

Wenqiang Li[1], Juanqiong Gou[1], Shuyao He[1], Zhe Wang[2]

[1] School of Economic and Management, Beijing Jiaotong University, Beijing, China
{20120606, jqgou}@bjtu.edu.cn, 805559464@qq.com
[2] Shanghai Siye Network Technology Co., Ltd, Shanghai, China
447255981@qq.com

Abstract. Virtual simulation can help students and enterprise employees to understand the company systematically and gain insights into the complexity and uncertainty of the enterprise 's digital innovation. The design focus of the virtual simulation teaching platform needs to base on the business and data of the enterprise. Considering authenticity and interest, the simulation rules are designed to adapt to the simulation needs of different business situations of various enterprises in a more flexible way. Therefore, this paper proposes a three-layer framework and implementation Methodology for extracting and configuring simulation rules, which can realize simulations of different business quickly and provide support for teachers in teaching. The implementation methodology of rule configuration serves for the three-layer framework. The paper takes rule configuration of a virtual simulation as a case to illustrate the proposed framework and methodology.

Keywords: Simulation Rule, Simulation Platform, Simulation Teaching, Rule Configuration

1 Introduction

Currently, the global digital infrastructure including social media, the Internet of Things, digital business platforms, and other digital networks and ecosystems is gradually being improved. It enables people, technologies, processes, and organizations complete hyper-connections and interdependence with each other, which intensifies the complexity of the entire digital world. The nonlinearity, self-organization, co-evolution, bifurcation and other characteristics of the entire complex socio-technical system inevitably has led to an unpredictable state which is called uncertainty[1].

In the discipline of Information Management, the intersection and integration of management and technology are difficulties. The complexity and uncertainty in digital innovation has further exacerbated the dilemma of students' learning and innovation, which brings challenges to the teaching of Information Management and other subjects. In regard to the teaching in college, how to help students better understand enterprise business and gain insight into the complexity and uncertainty of enterprise digital innovation has become more and more important [2].

Virtual simulation can inject people into virtual core roles through enabling, decision-making, communication, etc. [3]. Specifically, business simulation uses the same variables, relationships and events in the business world to simulate business reality. Through designing basic rules, relationships and market dynamics in enterprise business, simplifying the complexity of real companies and highlighting content and rules, the students can better understand enterprise business, personally experience enterprise decision-making behavior [2], and face the uncertainties in the process of business operations. Also, students can deeply experience the business of different companies through "immersive learning". Therefore, the simulation teaching can improve students' comprehensive implementation ability, comprehensive strategy ability, innovation ability, and cultivate students' sense of cooperation and team spirit [4]. However, the cost of developing simulation teaching platforms for different companies is relatively high. Also, it cannot meet the teaching tasks of different disciplines. Faced with the demands for mass customization, product configuration design is a key technology for rapid design and rapid response to the market demands [5]. Therefore, for the diversified needs of business simulation, a configuration platform is needed. Based on predefined components and constraint relationships, product configuration design can quickly form a personalized product BOM (Bill of Materials, BOM), which can meet the diverse needs of customers [6].

Product configuration design includes four aspects: components, product structure, configuration rules and constraints [6]. Specifically, configuration rules are important parts of product configuration design [5]. Because the primary task of product configuration is to translate customer knowledge into engineering knowledge. The bridge between these two knowledge domains is achieved by configuration rules [6]. Simulation rules are defined as the mapping relationship between simulation platform operation and enterprise business. Some institutions have begun to pay attention to the accumulation, organization, management and reuse of simulation models [7], but there are few researches on the configuration of simulation rules. Simulation analysis generates a lot of data, which hides a lot of useful knowledge [8]. This knowledge contains a large number of simulation rules. Extracting and reconfiguring these rules can help to improve an existing simulation teaching platform, or configure a new simulation teaching platform quickly which is similar and has a certain of differences with the existing business simulation platform. Under this context, this paper proposed following main question:

> *How to extract the simulation rules of the simulation teaching platform, enable this platform to achieve flexible iterative update based on this rule, and enable the platform to meet other business extension requirements based on the configuration of simulation rules.*

The paper is structured as follows: Section 1 introduces the research issues. Then, section 2 provides an overview of simulation research. Section 3 describes the three-layer framework for configuration of simulation rules based on the simulation teaching platform, which includes the extraction of rules, and gives specific implementation methodology. Section 4 provides a short case to help illustrate the framework and methodology. Finally, Section 5 gives conclusions and opportunities for further work.

2 Related Works

Simulation is not a new tool and used in many fields. For example, simulation is applied to supply chain configuration[9]. Also, many business decisions and process can be supported by various types of simulation platforms. Business domain simulation has been developed for decades and widely used in different fields, such as setup, planning and control [10]. Virtual simulation improves the conversion speed from theory to practice, and helps learners understand enterprise business more quickly to save time and cost [11]. Virtual simulation has been proved to be conducive to the understanding of theoretical knowledge, and can enhance the cognition of enterprises. In 2008, Hancock and others defined virtual simulation as a simulation that injects people into the virtual core role through enabling, decision-making, communication and other aspects [12]. Therefore, virtual simulation can help students to understand the complexity and uncertainty of enterprise.

Simulation teaching is an important part of realizing the information construction of higher education through the cross collaboration of multiple technologies. Simulation teaching platform can be divided into technology teaching and ability teaching through teaching objectives. Specifically, technology teaching is to realize the cognition of things or processes through virtual simulation, which is mainly applied to the teaching of medicine and nursing, engineering machinery, chemical biology and so on. Simulation teaching in medical care is particularly important after COVID-19 [13]. In addition to the construction of medical nursing virtual environment, in order to enhance students' cognition of medical and nursing knowledge, more and more researches on the simulation of patients' feelings [12]. Ability teaching is to form relevant consciousness or idea through virtual simulation teaching, so as to establish the ability to solve related problems. It is mainly applied to humanities and social sciences. For example, schools set up "training company" games to cultivate students' ability to communicate and solve communication problems [14].

Game simulation teaching has the characteristics of good interest [2], good interaction and strong creativity [15]. Therefore, the concept of serious game is brought into the virtual simulation teaching, so that students can feel the sense of competition, control and belonging in the simulation. Game simulation can stimulate students' internal needs and make them study actively. The game is a complex but intuitive system [16], including multimedia and simulation technology, as well as story interaction. Students' learning in game simulation teaching is a kind of self behavior. It is believed that the internal needs and emotions of drive are the motivation sources of self-determination behavior.

Virtual simulation has many applications in the field of teaching, including medical teaching, engineering teaching, business teaching, etc., and even adds the concept of game to increase the fun of simulation. This research is mainly about the teaching in the business field. When designing the simulation teaching platform, it is inevitable to embed the business process in the simulation. Faced with diversified business, we should establish a product configuration platform, in which rule configuration is an important content [5]. There are many studies researched about simulation teaching applications and simulation model reuse, but few of them focused on Rules. There are a lot of rules in simulation. Based on this, this paper focuses on the rule extraction of existing simulation platform and configuration of simulation rules.

3 Configuration Framework of Simulation Rules

In the design of simulation teaching platform, different types of business have different processes, so we need a flexible way to realize the simulation teaching platform to meet different business needs. At present, some organizations focusing on simulation teaching have implemented the configuration of simulation platform for different businesses, but the rule configuration process is difficult to be understood by others, and can not complete the rule configuration quickly and flexibly.

In order to meet the requirements of configuration of simulation rules, a three-layer configuration framework and configuration implementation methodology is proposed in this section, which can extract simulation rules and configure simulation rules from simulation teaching platform that is a problem-oriented platform.

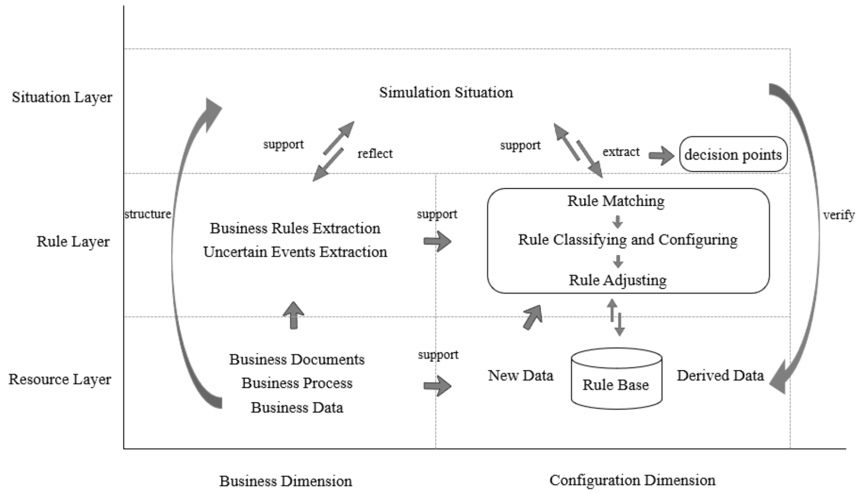

Fig. 1. Configuration Framework

As shown in Figure 1, the proposed configuration framework includes two dimensions: (1) business dimension, (2) configuration dimension; and three layers: (1) situation layer, (2) rule layer, (3) resource layer.

Situation layer: The configuration dimension and business dimension of this layer are represented as simulation situations. From the simulation situations, the decision points of collaborative situations can be extracted, which is the embodiment of simulation rules in the simulation situations.

Rule layer: In the business dimension, it is represented by the extraction of business rules and uncertain events which are needed to support the rule configuration process. In the configuration dimension, it is shown as the matching of simulation rules, the classification and configuration of rules, and the adjustment of rules. The configuration rules are divided into three parts: (1) basic data, which are directly from the data of the enterprise and do not need to be changed; (2) Rules Based on actual data, which are from the data of the enterprise but need to be adjusted; (3) Rules Based on simulation knowledge, which are designed because of the need of simulation [6].

Resource layer: In the business dimension, it represents the business documents, business processes and business data of the target enterprise. In the configuration dimension, it is the rule base of the corresponding business simulation, the new data which can support rule configuration and the derived data generated in the process of new virtual simulation. The data in the business dimension supports the newly constructed data in the configuration dimension.

In the business dimension, the business rules and uncertain events are extracted through the business documents, business processes and business data in the resource layer. The simulation situations are initially constructed. The simulation situations have no rules, but can be compared with the simulation template to select the appropriate simulation model. In the configuration dimension, the collaborative situation decision points are extracted from the selected simulation situations, and the collaborative situation decision points are matched with the corresponding rules of the simulation situations. This step mainly solves the problem of understanding rules. Then the rules are classified, configured and adjusted. The newly generated rules are stored in the rule base. The rationality of the new simulation rules is verified by the derived data generated by the new simulation teaching platform.

The above framework illustrates the whole process of rule configuration. In order to further illustrate the most important process of rule layer of the configuration dimension, the implementation methodology of configuration of simulation rules is proposed. The process involves multi-role and multi-agent cooperation, so the methodology is designed based on the metamodel for collaborative situations [17]. As shown in Figure 2, the methodology includes five main parts: collaborator, behavior, rule, objective and resource.

Rules are co-configured by partners. The configuration steps are as follows: (1) Mining collaborative situation decision points in simulation template based on simulation platform. (2) Based on the simulation data, the rule base is matched with the decision points of the collaborative scene. (3) New rules are classified and configured based on business resources and simulation data. (4) The rules after configuration are adjusted based on business resources and simulation data.

The decision points of collaborative situation are represented by behavior tree. The concept of behavior tree and corresponding application in the system was first proposed by Dromey in 2001 [18]. Based on the behavior tree, this paper redefines its traversal rules to illustrate the decision-making behavior in virtual simulation.

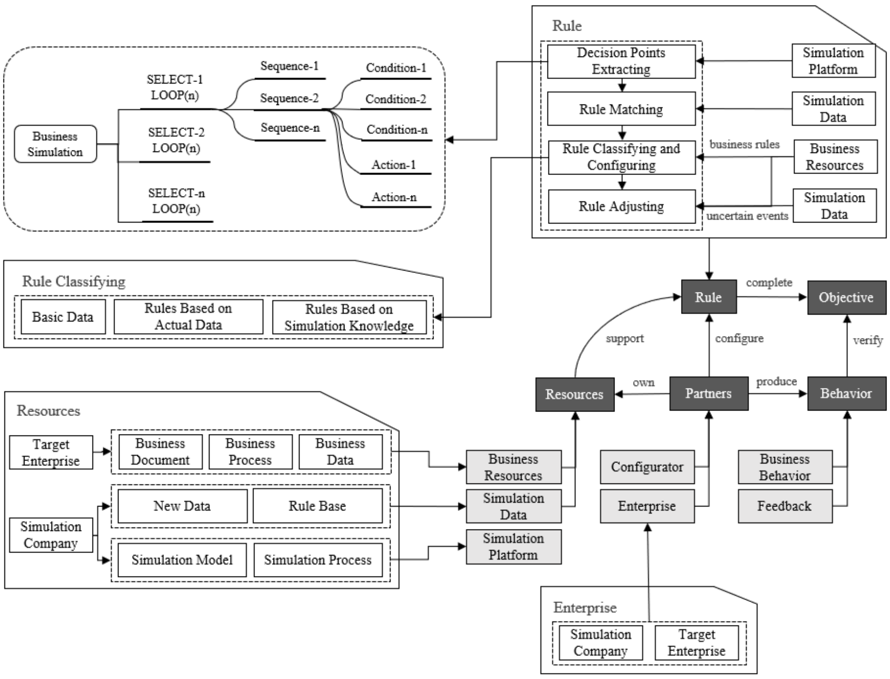

Fig. 2. Implementation Method Based on Configuration Framework

The behavior tree has four nodes: Select Node, Sequence Node, Condition Node and Action Node. (1) Select node: no matter whether the execution of the child node is successful or failed, all the child nodes will be executed in sequence, and success will be returned. Select node has the concept of LOOP (n), which means to repeatedly execute select node n times. (2) Sequence node: all the child nodes are executed in sequence, all of them succeed and return success. One node fails and stops traversing and returns failure. (3) Condition node: judge the condition, and the configuration rules correspond to the Condition node. (4) Action node: execute action according to the result of Condition node, which is the user's operation in the simulation platform.

The implementation methodology is goal-oriented methodology. In order to achieve the configuration goal, the configurator configures the rules according to the resources provided by the enterprise. After completing the new simulation teaching platform, business behavior and feedback are carried out to verify the rationality of the configuration rules.

4 Case of Simulation Rule Configuration

To better illustrate how the framework and implementing method described in Section 3 should be applied in real situations, a brief case of rule configuration was conducted in a business simulation rule configuration. In order to highlight the specific process of rule configuration, this case mainly illustrates the operation process of configuration dimension and simplifies the process of business dimension based on implementation methodology.

The background of this case is the simulation of the sales business of an outdoor products company. The following example calls the enterprise the target enterprise, which provides the business process of sales business, sales data, commodity information and supplier information. The cooperative enterprise of this example also includes a simulation company which has a simulation configuration platform. The platform can meet most of the requirements of business simulation configuration. However, the configuration of simulation rules is cumbersome, and it is difficult for people outside the company to understand.

By investigating the relevant business documents and processes of the target company's sales business, it is found that the sales business to be simulated by the target company is similar to the new retail simulation. Simulation company provides necessary resources. Based these resources and the representation method of the decision points of collaborative situations proposed in section 3, the decision points of new retail simulation are sorted out, some of which are shown in Figure 3.

Sales Business	SEL: Demand Research	......	......
	SEL: Customer Development LOOP(2)	SEQ:Customer Development	......
		SEQ: Recruiting Customer Developers	......
			CON: Recruitment Fee <= Holding Fund
			CON: Development Manpower< Required Quantity
			ACT: Recruiting Customer Developers
		SEQ: R & D Qualification Certificate	CON: R & D Expenses <= Holding Funds
			CON: R & D Personnel >= Required Quantity
			ACT: R & D Qualification Certificate
		SEQ: Recruitment of R & D Personnel	......
	SEL: Receiving Orders LOOP(2)	......	......
	......	......	......

(a)

matching

Rule Base

category	fieldname
goods	goods information
	profit
	arrival period of goods
customer	customer name
	payment proportion
	customer development expenses
	number of employees consumed in negotiation lead time
skill	skill name
	skill development costs
	number of skilled R & D personnel
certificate	certificate name
	certificate development fee
	number of certificate R & D personnel
human resource	name of personnel
	personnel salary
	recruitment costs
	dismissal expenses
storage	Inventory quantity
logistics	logistics mode
	logistics cost
customer order	order quantity
	total order price

(b)

Fig. 3. Decision Points Based on Collaborative Situations

Figure 3 (a) shows any situations of the new retail sales business. (1) Demand Research is used to find suitable customers for the enterprise. (2) Customer Development is used to develop the selected customers. (3) Customer Order is used to receive orders. SEL is Select Node. Seq is the Sequence Node. Con is Condition Node. Act is Action Node. The relationship between nodes and node traversal rules are based on the definition in section 3. The attribute of LOOP (2) is given to customer development to complete the operation of customer development.

Condition Node in the figure is the premise of Action Node operation. For example, in the "SEQ: R & D Qualification Certificate" node, the premise of "ACT: R & D Qualification Certificate" is "CON: R & D Expenses < = Holding Funds" and "CON: R & D Personnel > = Required Quantity". If any of the conditions is not met, the "ACT: R & D Qualification Certificate" cannot be issued. The next process is to traverse the "SEQ: R & D Personnel Recruitment". After completion, because "SEL: Customer Development" has the attribute Loop (2), it is necessary to traverse this SEL node again. The rule corresponds to the Condition Node.

After the extraction of the decision points of collaborative situations, configuration rules need to be matched. Figure 3 (b) shows the related rules in the rule base. These existing rule tables are goods, customer, skills which is needed to sell or process a commodity, certificate which is provided by the enterprise for selling products, human resource, warehouse, logistics and customer order.

Table 1. Simulation Rule Matching

Decision Point		Category	Rule Information
Con: the profit of needed goods meets the expectation	>>	goods	Goods information
Con: the profit of needed goods meets the expectation	>>	goods	profit
Con: customer lead time meets expectations	>>	customer	Lead time
Con: customer lead time meets expectations	>>	customer	Customer name
Con: customer payment ratio meets expectations	>>	customer	Payment proportion
Con: the delivery period of goods meets the demand of delivery period	>>	goods	Arrival period of goods
Con: Sales / processing skills	>>	skill	Skill name
Con: development cost < = capital held	>>	skill	Development cost
Con: R & D personnel > = required quantity	>>	skill	Number of R & D personnel
Con: recruitment fee < = holding fund	>>	human resources	R & D personnel recruitment costs
Con: recruitment fee < = holding fund	>>	human resources	Cost of R & D personnel dismissal
Con: the salary of R & D personnel meets the expectation	>>	human resources	Salary of R & D personnel
Con: development cost < = capital held	>>	customer	Development cost
Con: own R & D certificate corresponding to the market	>>	certificate	Certificate name
Con: the number of employees needed to develop the market	>>	human resources	Employee name
Con: development manpower < required quantity	>>	human resources	Market developer
Con: R & D expenses < = holding funds	>>	certificate	Development cost
Con: R & D personnel > = required quantity	>>	certificate	Number of R & D personnel
Con: item stock > = scheduled quantity	>>	storage	Inventory quantity
Con: mode of transportation > target expectation (cost + timeliness)	>>	logistics	Logistics mode
Con: mode of transportation > target expectation (cost + timeliness)	>>	logistics	Logistics cost
Con: delivery time < = deadline	>>	customer	Lead time
Con: delivery time < = deadline	>>	order	Order quantity

Through rule matching, the configurator can make clear the meaning of configuration rules and what part of simulation configuration rules act on. The following Table 1 shows the matching table (taking some of them for example) between the decision points of collaborative situations and the simulation rules.

In the Table 1, the corresponding rules in the Condition Node are extracted. Among them, the information in the black dotted circle is the Condition Node and the corresponding rules in the example of decision points given above. A condition may correspond to one or more rules.

Rule Classifying and Configuring

category	fieldname	value
basic data	Commodity information	pizex
	Customer name	China Mobile
	Name of personnel	Key Account Manager
Rules Based on actual data	Arrival period of goods	1
	Cost of goods	1071.14
	Selling price	1969.54
	Lead time	3
	Payment proportion	30%,50%,20%
	Development cost	120000
	Personnel salary	6000
	Recruitment costs	15000
	Dismissal expenses	9000
	Inventory quantity	5000
	Logistics mode	Air transport
	Logistics cost	1000
	Number	275
	Total price	541475
Rules Based on simulation knowledge	Skill development costs	9000
	Customer development expenses	9000
	Number of skilled R & D personnel	2
	Certificate name	Quality management system certification
	Skill name	Construction of environmental management system
	Number of certificate R & D personnel	1
	Name of personnel	R & D management

(a)

Rule Adjusting

Fieldname	Adjustment
Payment proportion	30%,50%,20%|40%,40%,20%
range of demand quantity	250-300
range of demand price	89%-100%

(b)

Fig. 4. Rules Configuration and Adjustment

As shown in Figure 4, the sorted rules are classified and configured. Figure 4(a) shows the classification of rules. Rules are designed based on the business data provided by the target company. Figure 4 (b) shows the adjustment of rules based on uncertain events. The payment proportion of customers is random, so two payment proportions of "30%, 50%, 20" and "40%, 40%, 20%" are set. For the users of the platform, less initial payment from customers may lead to the rupture of the enterprise cash chain. There may be differences in the quantity and price of goods that customers need in different periods. Therefore, the value of demand quantity and demand price is set as interval value to simulate the real situation.

This case illustrates the three-layer framework and the implementation methodology of rule configuration by configuring the sales business of a target enterprise (the sales business of the target enterprise is similar to the sales business of the simulation company's new retail simulation). Configurators can meet the requirements of rule configuration in a more flexible way.

5 Conclusion

Faced with the simulation requirements of multiple businesses, configuration of simulation rules is particularly important. A rule configuration framework and corresponding configuration implementation methodology are proposed. It can meet various learning tasks such as cognition of operation and management complexity, reverse engineering of demand analysis and design, design and configuration of intelligent industrial interconnection system, and data analysis of operation and management behavior.

The main innovation of this paper is to extract the decision points of collaborative situations from the simulation platform, and find the rule source of the simulation platform on this basis. Combined with the three-layer framework and configuration methodology, it provides a reference idea for rapid configuration of rules. The future work will focus on the design of components and constraints of configuration platform and the development of configuration platform.

Acknowledgements. The presented research works have been supported by "the National Natural Science Foundation of China" (61972029).

References

1. Benbya, H., Nan, N., Tanriverdi, H., Yoo, Y.: Complexity and Information Systems Research in the Emerging Digital World. MIS Q. 44(1), 1-17 (2020).
2. Borrajo, F., Bueno, Y., de Pablo, I., Santos, B., Fernández, F., García, J., Sagredo, I.: SIMBA: A simulator for business education and research. Decision Support Systems. 48, 498-506 (2010).
3. Foronda, C. L., Fernandez-Burgos, M., Nadeau, C., Kelley, C. N., Henry, M. N.: Virtual Simulation in Nursing Education: A Systematic Review Spanning 1996 to 2018. Simulation in Healthcare.15(1), 46–54 (2020).

4. Zhang, L.: Design and Practice of Virtual Simulation Experiment Teaching Center for Modern Enterprise Business Operation. In: Deng D. (eds.) ACSS 2015. Advances in Social and Behavioral Sciences, vol. 15, pp. 65-70. Singapore Management and Sports Science Institute, Paris(2015).
5. Ren, B., Zhang, S.: Knowledge Acquisition from Simulation Data to Product Configuration Rules. Advanced Materials Research. 308-310, 77-82 (2011).https://doi.org/10.4028/www.scientific.net/AMR.308-310.77.
6. Chen, Z., Wang L.Y.: Adaptable product configuration system based on neural network. Internation Journal of Product Research. 47, 5037-5066 (2009). http://dx.doi.org/10.1080/00207540802007571.
7. XiongSong. Reusability Implementation Method of Large-scale Simulation Model Architecture. Modern Navigation. 2016, 7(2): 131-136.
8. Yin, J.L., Li, D.Y., Peng Y.H.: Knowledge acquisition from metal forming simulation. International Advanced Manufacture Technology. 29, 279-286 (2006).
9. Fornasiero, R., Macchion, L., & Vinelli, A. (2015). Supply chain configuration towards customization: a comparison between small and large series production. IFAC-PapersOnLine, 48(3), 1428-1433.
10. Jahangirian, M., Eldabi, T., Naseer, A., Stergioulas, L.K., Young, T.: Simulation in manufacturing and business: A review. European Journal of Operational Research. 203, 1-13 (2010).
11. Musselwhite, C.: University Executive Education Gets Real. Training and Development Magazine. 6, 57–59 (2006).
12. Thompson, J., White, S., Chapman, S.: Virtual patients as a tool for training pre-registration pharmacists and increasing their preparedness to practice: A qualitative study. PLOS One. 15(8) (2020). https://doi.org/10.1371/journal.pone.0238226.
13. Sahi, P. K., Mishra, D., Singh, T.: Medical Education Amid the COVID-19 Pandemic, Indian Pediatr. 57(7), 652–657 (2020).
14. Gareyeva, E. A., Dubinina, E.: The 〈Training Firm〉 as a Way of Implementing a System- and Activity-Based Approach to Teaching in Higher Education Institutions. Tomsk State Univ. 457, 175–186(2020).
15. Hamalainen, R.: Designing and evaluating collaboration in a virtual game environment for vocational learning. Comput. Educ. 50(1), 98–109 (2008).
16. Sauve, L., Renaud, L., Kaufman, D., Marquis, J.S.: Distinguishing between games and simulations: A systematic review. Educ. Technol. Soc. 10(3), 247–256 (2007).
17. Benaben, F., Li, J., Koura, I., Montreuil, B., Lauras, M., Mu, W., Gou, J.: A Tentative Framework for Risk and Opportunity Detection in A Collaborative Environment Based on Data Interpretation. In: Proceedings of the 52nd Hawaii International Conference on System Sciences, pp. 3056-3065. ScholarSpace, Hawaii (2019). http://hdl.handle.net/10125/59742.
18. Dromey, R.G.: From requirements to design: Formalizing the key steps. In: Cerone, A. and Lindsay, P. (eds.) First International Conference on Software Engineering and Formal Methods, Proceedings. pp. 2–11 (2003).