EMPLOYMENT OF BUSINESS INTELLIGENCE METHODS FOR COMPETENCES EVALUATION IN BUSINESS GAMES

Olga Vikentyeva, Alexandr Deryabin, Nadezhda Krasilich, Lidiia Shestakova

Abstract: *This research involves justification of Business Intelligence methods usage in order to analyze the outcome of computer-based business games. In such games, it is necessary to evaluate efficiency of player's actions that is associated with the development of professional competences acquired by participants as well as the game effectiveness in regard to the qualitative development of the specified competences. Computer-based business games development and conduction is performed within the source environment of "Competence-based Business Games Studio". The challenge of player's competences evaluation and the game effectiveness is tackled by Business Intelligence methods implementation into analysis subsystem of "Competence-based Business Games Studio". The analysis of participants' actions allows getting player's behavior characterization based on the information about the results of all games that the player participated. In order to guide the course of the business game, analysis is conducted on the basis of all players' actions during all games and the reference models of the games. The paper defines data source subsystems and the main measurements; it also considers the process of data warehouse development and the requirements to the output of analysis subsystem.*

Keywords*: business intelligence methods, data warehouse, competencies, active learning methods, business-game.*

ACM Classification Keywords*: K.3 Computers and Education: K.3.2 Computer and Information Science Education – Information systems education. K.4 Computers and Society: K.4.3 Organizational Impacts – Employment. I. Computing Methodologies: I.2 Artificial Intelligence: I.2.1 Applications and Expert Systems – Games.*

Introduction

Currently, significant changes in education area are taking place. These changes are triggered by new requirements to graduates, intensification of labor force market competition, emergence of new professions, spread of information technologies and international integration in education sector. This makes traditional approaches to the educational process impossible to use.

Therefore, competence building is becoming the main purpose of education. Competency is defined as the ability to implement knowledge, skills and personal qualities to succeed in a certain professional area. For competences' formation it is necessary to use new forms of education, that improve cognitive, communicative and personal student activity. In this case, active forms of education such as training, role-playing games, case study, business games, computer simulators are gaining popularity. The thematic justification is evidenced by numerous publications of Russian and foreign authors [Biggs, 1990], [Draganidis, 2006], [Aldrich, 2009], [Girev, 2010], [Vikentyeva, 2013], [Bellotti, 2013], [Bazhenov, 2014].

The standard approach to competences' evaluation process implies testing and estimation of its results. However such approach leads to low accuracy of competences' level determination [Bellotti, 2013].

At the same time, there are alternative methods of competences' assessment. Nowadays there is a great interest in business games that are included in the subset of serious games. Business games aim to build competences' within educational process. A review of existing researches in evaluation of the business games efficiency and its' participants actions is conducted in the research of [Bellotti, 2013].

In business games it is necessary to evaluate the players' actions efficiency that is associated with the results of competences' development. Participants' actions evaluation process will allow to design individual educational trajectory for each player, as well as to provide feedback to the player. Furthermore, the game quality evaluation is required in order to conclude whether the game is suitable for the development of given set of competences.

The "serious" games adopted the following approach to competences formation assessment. The game is divided into several levels and each level corresponds to some level of competences' development. Therefore, the gameplay of such a game should comply with educational goals. Thus, the following aspects can be identified: a participant actions assessment; a participant actions characterization that includes the game (scenario, level of complexity and so on) characterization and characterization of a player (individual information); inclusion of assessment into a game [Bellotti, 2013].

Such an approach, however, is prone to the following issues:

– The difficulty of obtaining personal information, for instance, neurophysiological signals analysis required the use of complex equipment.

– The complexity of the assessment mechanism implementation into a game, i.e. the game scenario has to include training elements and the evaluation of training results.

Therefore the challenge of the research is identification of evaluation methods of competences acquired by a player during a business game conduction.

Business Intelligence Methods using in Educational Processes

Business Intelligence (BI) is a direction in data processing, that helps to make a decisions in different situations based on meaningful information for given domain. BI methods include an information provision, integration and analysis tools.

Information analysis methods encompass the following:

– OLAP (Online Analytical Processing) represents multidimensional analysis where each dimension includes data consolidation consisting of sequential generalization levels, each level corresponds to more aggregated for the relevant dimension data. OLAP provides the following features to operate with multi-dimensional data: flexible review of information, optional data slices, drill down, drill up, rotation, inter-temporal comparisons.

– Data Mining is used to highlight the significant patterns in data that is stored in data warehouses. Data Mining is based on statistical modeling, neural networks, genetic algorithms, etc. Problems solved by Data Mining Methods include: classification – objects (observations, events) assignment to one of previously known classes, regression including forecasting tasks, identification of dependency in continuous variables, clustering – objects (observations, events) grouping based on data (properties) describing the nature of these objects, association – identification of patterns between the time-related events, variance analysis – identifying the most atypical patterns.

Educational Data Mining (EDM) – DM methods implementation for analysis of data, generated by educational processes in order to solve educational challenges such as adaptation of the curriculum for a particular learner, improving the understanding of the learning process and so on.

As of today, there is a number of researches in EDM domain. However, these researches have a fairly wide range of goals, i.e. authors use similar data sets but they pursue completely different goals, for instance:

- Schedule planning and scheduling.

- Preparation of recommendations for students.

- Predicting student performance.

- Determination of undesirable behavior of students.

- Splitting students into groups according to their personal qualities.

- Educational software development.

The figure 1 represents the concept of most such systems [Hung, 2012]. This algorithm can be applied in absolutely different studies, for example, determination of factors that have influence on students' progress [Jeong, 2013], failure on exam prediction [Sahedani, 2013], study of on-line learning improvements ways [Hung, 2012], etc.

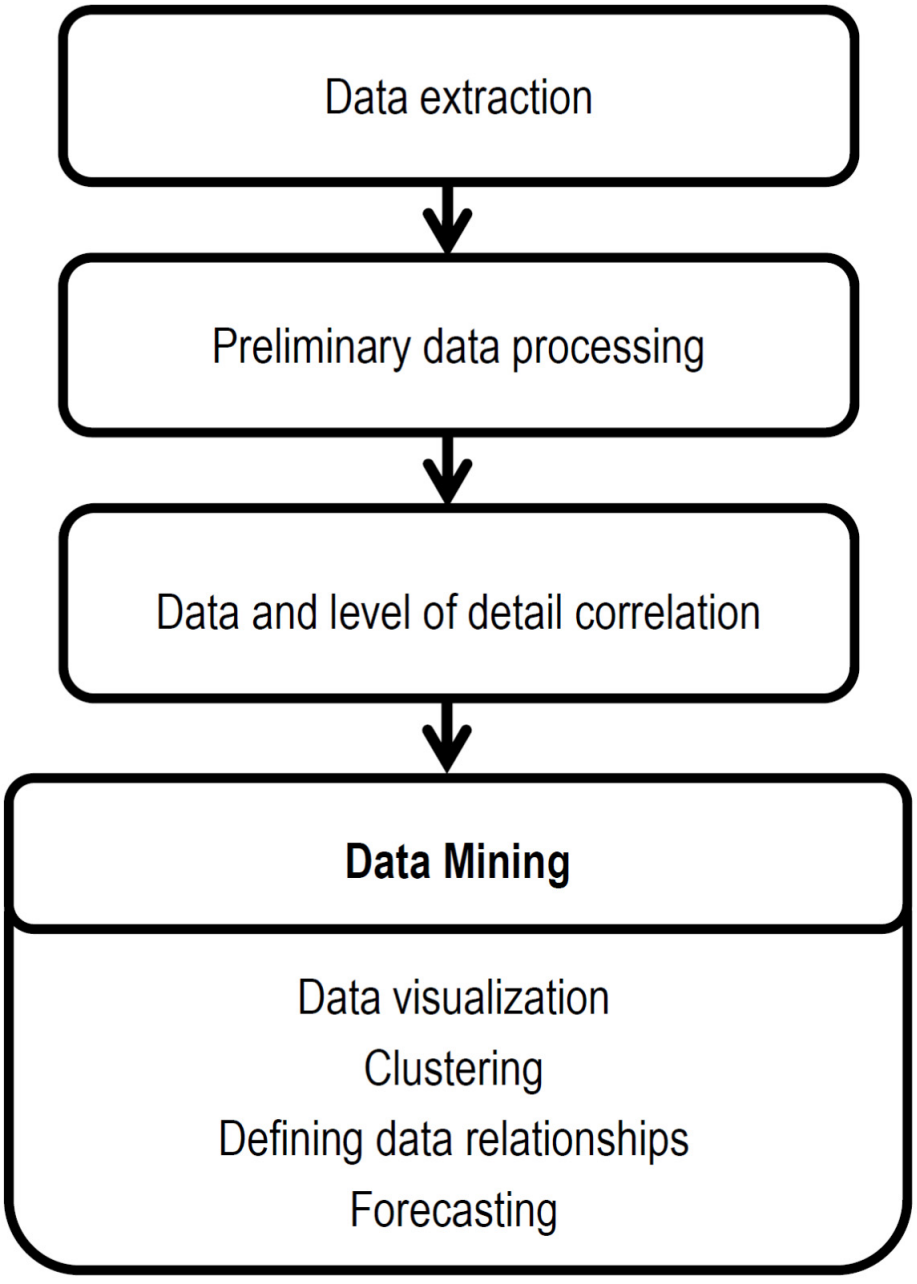

Figure 1. Generalized algorithm of EDM-systems performance

Information System of Business Games Design and Conduction

Business games development and conduction may be carried out with use of information systems. Competence-based Business Game Studio (CBGS) information system includes tools for game designing, game conduction, measurement of obtained competences, game process monitoring, player's actions analysis and business game analysis, player's behavior correction and game scenario correction [Vikenteva, 2013].

Competence is a combination of knowledge, skills, experience and personal characteristics of an employee that are necessary to carry out his professional duties successfully [Kozodaev, 2015].

CBGS analysis subsystem should provide assessment of player's competences (knowledge, skills and experiences) based on his actions within Decision Making Points during game conduction [Formalization of Domain]. Decision Making Points allow participant to choose the course of action within a business process. The design subsystem includes the reference model of game, against which actual data of player's actions may be compared. CBGS information contours associated with analysis subsystem are represented on figure 2.

Analysis subsystem should perform business game analysis based on comparison of the results of different participants' actions. Based on data obtained from analysis subsystem the correction of player's behavior may be performed. This allows developing individual educational trajectory for each player (contour A). Moreover, correction subsystem allows changing elements of business games in order to reset it for more qualitative development of defined competences (contour B).

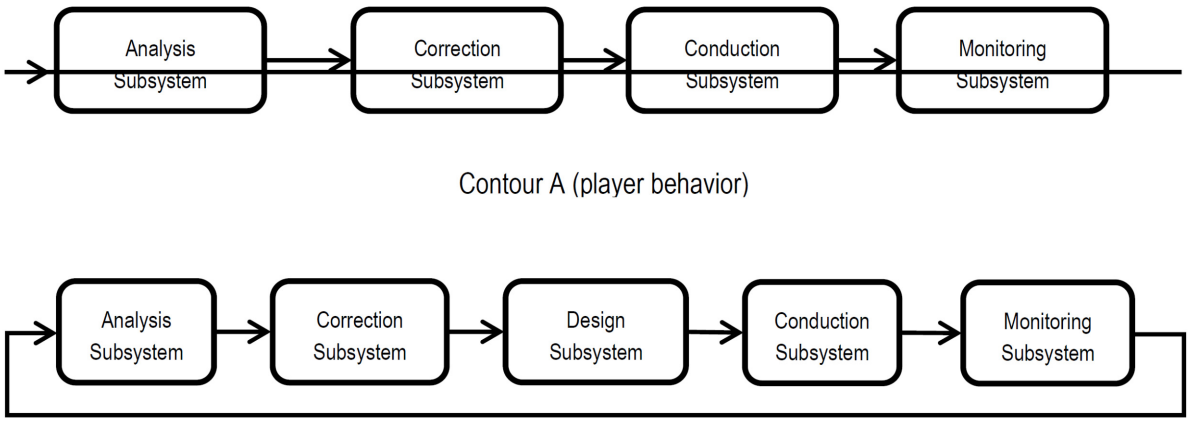

Figure 2. CBGS information contours related to analysis

Analysis Subsystem should perform two major analysis procedures:

1. Player's actions analysis that allows providing player's characterization based on all business games, which the player participated.

2. Game analysis to its correction in the case of bottlenecks identification. For such an analysis input data is information about all players' actions during all games and the reference models of all games.

In order to develop analysis subsystem it is required to design data warehouse and define dimensions for player's and game's assessments.

Competence includes two major characteristics: knowledge and skills. Experience assessment will not be performed within business game. Therefore data mart designing for player's actions evaluation will be multidimensional and will consist of as least two dimensions. There is no limit to the amount of characteristics and key figures. They must be defined on the basis of business processes' characteristics.

The results of conducted games will be divided into clusters for the game bottlenecks identification. However in order to define the reason of these bottlenecks or errors it is required to set some patterns. This may be provided by usage of Data Mining method – instructed classification.

Initially results of all conducted games will be divided into clusters but in order to identify bottlenecks average clusters' characteristics will be compared with objects from the learning sample.

Thus in the process of CBGS analysis subsystem development the following Business Intelligence methods will be implemented (table 1, table 2):

– Slice and Dice.

– Drill Down/Up.

– Pivoting.

– Nesting.

– Clustering.

– Instructed Classification.

Table 1. Formalized representation of Business Intelligence method group selection

		Requirements for the Analysis Subsystem			
		Multi-dimensional data marts appliance	Patterns determination during game conduction	A comparison of patterns with the specified templates	Search of game process deviances from reference models
Groups of Business Intelligence Methods	Complex Analysis	yes	no	no	no
	Forecasting	no	no	no	no
	Business Forecasting Model	no	no	no	no
	Data Mining	yes	yes	yes	yes

Table 2. Formalized representation of Business Intelligence method selection

				Requirements for the Analysis Subsystem			
				Multi-dimensional data marts appliance	Patterns determination during game conduction	A comparison of patterns with the specified templates	Search of game process deviances from reference models
Business Intelligence Methods	Complex Analysis	Slice and Dice		yes	no	no	no
		Drill Down/Up		yes	no	no	no
		Pivot		yes	no	no	no
		Nesting		yes	no	no	no
	Data Mining	Clustering		no	yes	no	no
		Classification	instructed	no	no	yes	yes
			uninstructed	no	no	no	no
			self-learning	no	no	no	no
		Association		no	no	no	no
		Sequencing		no	no	no	no
		Regression		no	no	no	no
		Forecasting		no	no	no	no

Source Data for Analysis Subsystem

Source data for player's actions analysis are stored in following CBGS subsystems (fig. 3):

– Design Subsystem (contains competences' matrix for each operation and the reference models of business processes)

– Monitoring Subsystem (contains the results of conducted games by a player based on data acquired from Conduction Subsystem).

Source data for game analysis are formed by the Design Subsystem, including Competence Designing Module.

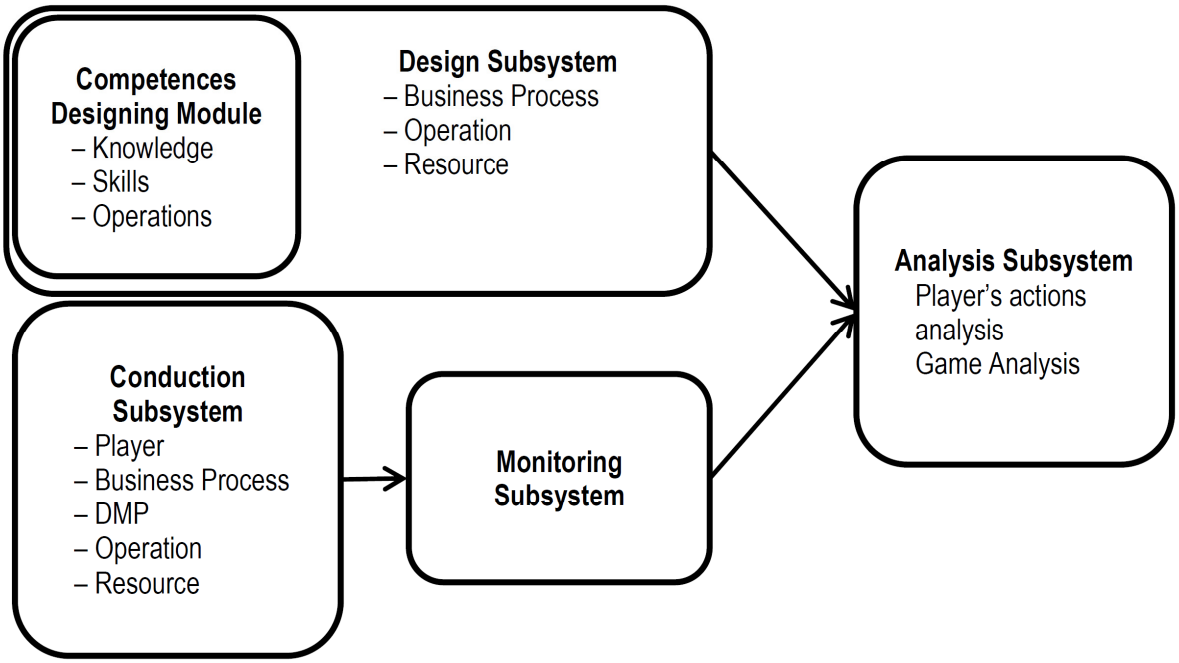

Figure 3. Source Data for Analysis Subsystem

The process of competence planning is resolved to a composition of business process operations' coverage matrix of competences. The matrix has to associate operations and competences (figure 4). However, it is important to define the extent to which the competence is obtained by a player and which knowledge and skills he has. In order to create this possibility, multi-dimensional array of competencies has to include resources, since they allow defining if a player possesses required set of knowledge and skills to perform operations within a business process (player knows which resources are needed and how to implement them).

			Competence 1				Competence 2				Competence u			
			Knowledge 1.1	Knowledge 1.r	Skill 1.1	Skill 1.l	Knowledge 2.1	Knowledge 2.q	Skill 2.1	Skill 2.w	Knowledge 1.1	Knowledge u.r	Skill u.1	Skill u.p
Business Process 1	Operation 1.1	Resource 1.1.1	1		1									
		Resource 1.1.2		1										
		Resource 1.1.x				1								
	Operation 1.2	Resource 1.2.1									1			1
		Resource 1.2.2											1	
		Resource 1.2.y					1		1			1		
	Operation 1.n	Resource 1.n.1						1						
		Resource 1.n.2								1				
		Resource 1.n.z												
Business Process t	Operation t.1	Resource 1.1.1	1		1									
		Resource 1.1.2		1										
		Resource 1.1.x				1								
	Operation t.2	Resource t.2.1					1							
		Resource t.2.2.						1	1					
		Resource t.2.f								1				
	Operation t.k	Resource t.k.1									1			
		Resource t.k.2										1	1	
		Resource t.k.g												1

Figure 4. Data Structure for Competences Planning

Figure 5 represents a simplified diagram of the Design Subsystem database that does not include secondary attributes; it means that each entity contains only those attributes that are meaningful for the Analysis Subsystem development.

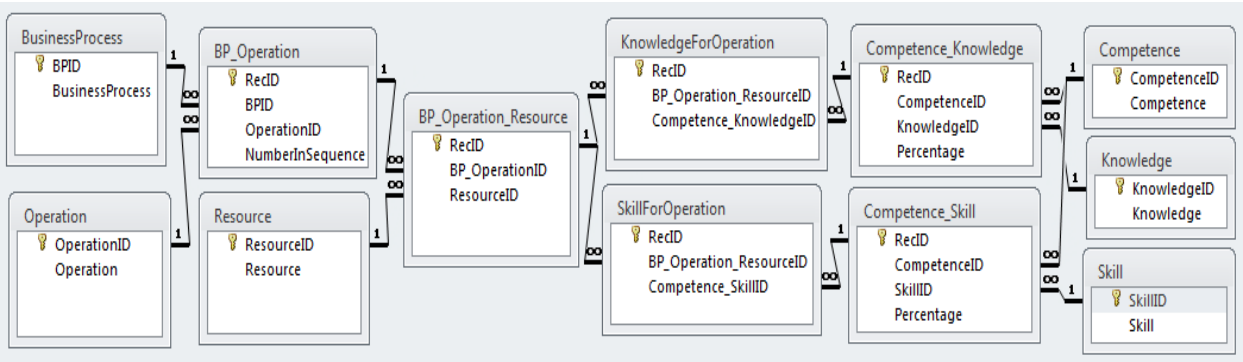

Figure 5. Database diagram for storage information about game

The simplified database diagram for storage of game results data can be seen on Figure 6. It represents log of operational data of conducted games by players.

Date and time of start and end of a game are stored in table “BP_Player”. Based on this data it can be determined whether the player has already played this game, and if he did, then how many times.

Table “BP_Player_Operation” stores actual number of operations performed by a player within a certain game. Thus, it is possible to define whether a player performs actions in the right order. Number of operations is derived from information about Decision Making Points and chosen resources.

Table “BP_Player_Operation_Resource” stores a set of resources chosen by a player in order to perform a certain operation within a business process. Data from this table together with the data from Competences’ Planning DB allow defining the extent of certain competences obtaining by a player.

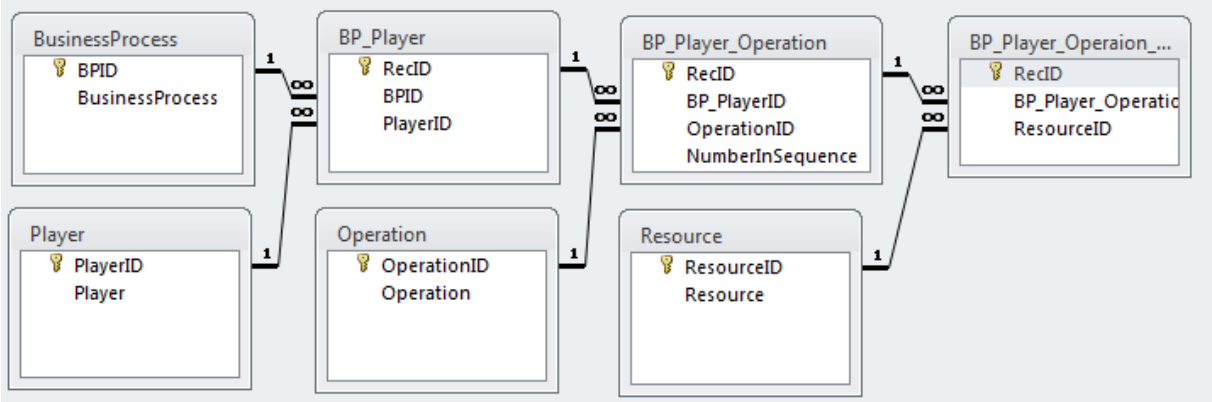

Figure 6. Results of Conducted Games Database Diagram

Databases of all subsystems are developed in DBMS MS SQL Server Management Studio.

As data of multi-dimensional cubes of data warehouse will be loaded from several subsystems (from several databases), requirements for source systems’ data models and data itself were formulated. Loaded data should require minimum change in steps of pretreatment and transformation.

Pretreatment of data implies data scrubbing from noise, getting rid of the redundancy and the selection of significant characteristics. Data transformation is required to bring the data to fit for further analysis mind.

The Analysis Subsystem Data Warehouse Designing

Based on source data that may be extracted from the Design Subsystem and the Monitoring Subsystem, it was revealed that players' actions assessment can be performed using the following criteria:

– Correspondence of operations sequence, performed by a participant during a game to the reference model.

– Player's expertise.

– Satisfactory time of game duration.

According to these criteria the data warehouse will consist of dimensions represented in table 3. Key figures (facts, measures) are shown in table 4.

Table 3. Dimensions

Name	Type	Length
A Game Duration	Time	-
Number of a Game for a Player	Integer	-
Business Process	String	255
Operation	String	255
Resource	String	255
Competency	String	255
Competency Type (Knowledge or Skill)	String	6
Knowledge/Skill Name	String	255
Operation Number of the Reference Model	Integer	-
Actual number of operation	Integer	-

Table 4. Key figures (facts, measures)

Name	Type	Unit of measure
The Deviation in Sequence	Integer	-
Operation Performance Indicator	Integer (0 or 1)	-
Formed Percentage of Knowledge/Skill	Double	Percentage

The physical model of data warehouse designed for player's actions assessment was developed within MS SQL Server Management Studio 2012. The diagram represents a database developed by the schema "Snowflake". The physical model of the cube "Assessment of Player's Actions" is presented on Figure 7.

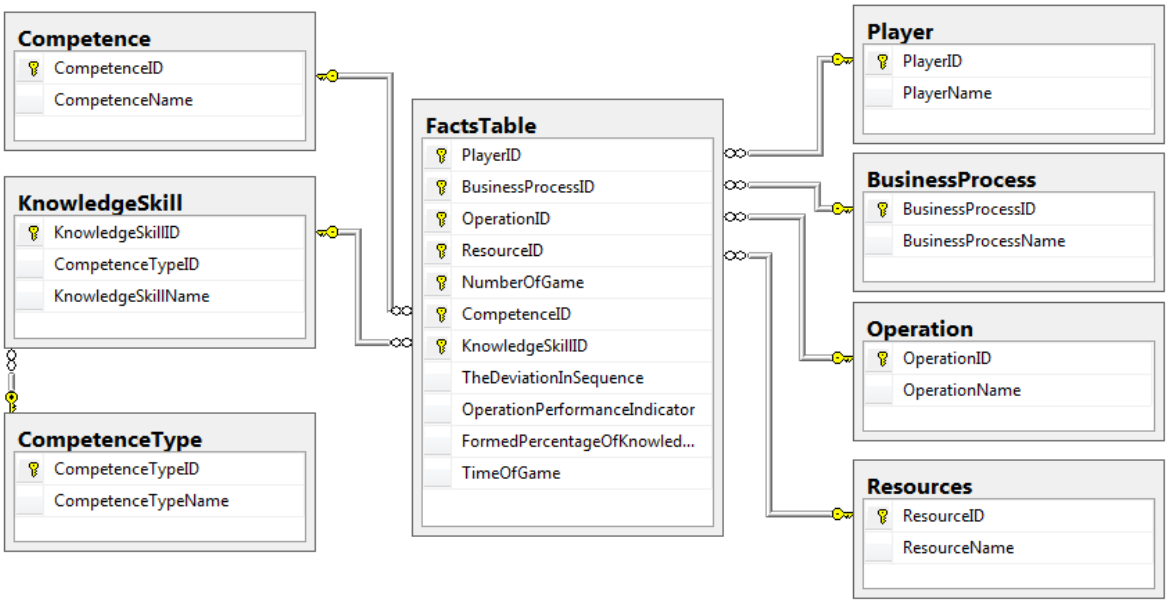

Figure 7. The Data Warehouse Diagram «Player's Actions Assessment»

The diagram contains a fact table and 7 tables of dimensions. The fact table includes a composite key containing references on all cube dimensions.

Conclusion

The research is devoted to the challenge of evaluation of competences obtained by participants during the computer-based business game playing and assessment of business game itself. Computer-based business game is designed and implemented within tool environment "Competence-based Business Game Studio" consisting of several subsystems. The paper describes the Analysis Subsystem development process. The subsystem is used to evaluate player's actions and business game quality.

During the research, data stored in source systems were considered. Based on this data major characteristics of the data warehouse were revealed. Moreover, the requirements for output data of the Analysis Subsystem were formulated. This allowed defining a set of needed key figures. The criteria for player expertise assessment were derived in the process of requirements development for competence-planning-related data storage.

During Business Intelligence methods' analysis it was revealed that in order to implement functional requirements to the Analysis Subsystem it is necessary to implement all tools of Complex Analysis as the designed data warehouse is multi-dimensional and different reports will be formed. To reveal bottlenecks in business processes and the business game instructed classification and clustering (Maximin Algorithm) will be used.

The data warehouse for player's actions assessment was designed and load, transformation flows were developed.

Further work includes OLAP-cube "Bottlenecks of the Business Game" development and clustering and classification methods implementation in order to create analytical reports within the task.

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