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Design and Application of a Decision Support Tool for the Selection of Logistics and Supply Chain Management Games*

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The focus of this paper is on the design and application of a new original decision-making support tool for the selection of logistics and supply chain management (SCM) educational games. The design of a decision support tool for the selection of these games (hereafter, DST SLSCMG) was followed by a case study which demonstrates the application of the DST SLSCMG, and the evaluation of the use of the games. The proposed DST SLSCMG is based on the database of 55 identified logistics and SCM games and components, which enable performing a multi-criteria analysis. It is applied at an engineering school for the selection of the most suitable games for two logistics and SCM-related courses. The results of the evaluation of the use of the games showed that students were very satisfied with the games selected with the help of the DST SLSCMG. The new DST SLSCMG offered here can help interested educators to assess the available logistics and SCM games and select the most suitable ones.

Keywords: games; decision support tool; logistics; supply chain management; selection.

1. Introduction

Engineering education is in a state of change. The traditional engineering curriculums primarily oriented to acquiring hard engineering skills have been enhanced to new ones where both hard engineering skills and professional skills are very important. These changes in many schools of engineering are going slowly and one gets the impression that the faster steps are required toward offering engineering programs and curriculums according to the industry needs (e.g. [1]). Introduction of logistics and supply chain management in the engineering programs and curriculums is one of the many efforts on that way. Many schools of engineering recognized the importance of the logistics and SCM field and offer courses and even study programs with the title 'logistics' and 'supply chain management', and similar, especially in the last decade [2–7], but still there are many more schools that should join them in the next years. In these schools, attention is given or will be given to the methods of teaching logistics and SCM, among which games are or expected to be very popular [1, 3–4].

Games have been developed and used in teaching logistics and supply chain management, as well as in other fields of engineering education for a long time [1]. Logistics and SCM educational games allow students to play different roles, e.g. a logistics engineer, a distribution network designer, an inventory manager, a supply chain engineer, a supply chain manager, etc., in an environment 'without real risks' that consists of virtual entities, such as products, factories, transport vehicles, distribution centers, wholesalers, retailers, etc. Most educators use at least one game, simulation and/or interactive exercise in addition to other teaching methods such as lectures and case studies for teaching logistics and SCM [2]. However, in most cases, logistics and SCM games are usually used in an ad-hoc manner; they are not integrated into the courses in the proper way [8]. Sometimes, educators only consider different versions of a well-known Beer Game [9] and choose to include it in the course without assessing other games. The important 'step' that is typically skipped by most educators is a serious assessment of available logistics and SCM games and a selection of the most suitable ones that would meet course requirements. The reasons can be very diverse: unavailability of some kind of decision-making support tool for the selection of logistics and SCM games; a time-consuming process to understand and test different games; costs required to purchase and/or use a game; hardware and software requirements for setting up a game; time required to set up a game; justification of in-house game development; valuation of outcomes of applied games; and the lack of motivation of educators (based on [1, 10–12]). Therefore, efficient and effective ways of mitigating these reasons and improving the process of selection of logistics and SCM games are very significant.

The focus of this paper is on the design and application of a new decision-making support tool for the selection of logistics and SCM games. The remainder of the paper is organized as follows. In the next section, a brief historical background about

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logistics and SCM games and several ways of their classification are given. Then, a five-stage research process is presented, followed by a description of the designed DST SLSCMG. A case study based on experience of an engineering school is then used to present the application of DST SLSCMG. Perceived satisfaction with selected games is examined in the following section. Finally, a discussion of the results and some concluding remarks are offered in the last two sections.

2. Logistics and SCM games

A number of logistics and SCM games have been developed in academic, military and commercial organizations. Their direct predecessors can be related to the efforts of Mary Birshstein during the 1930s in Europe to develop a 'game' to support training programs in the field of production and distribution [13]. During the 1950s and 1960s in the USA, the RAND Corporation, the Research Analysis Corporation, the Operations Research Office, the Army Logistics Center and the Army Management School developed and employed several army logistics games [13–14]. In the early 1960s, Professor John D. Sterman from the Massachusetts Institute of Technology (MIT) developed unquestionably the most famous logistics and SCM game—Beer Game (e.g. [9, 15–17]). The proliferation of logistics courses at universities and colleges in the 1970s [18] was followed by the development of specific games. Campbell et al. (1999) pointed at several logistics games suitable for students' education (cf. [15]). Ammar and Wright (1999) described their experiences with the use of eight games in addition to traditional lecture-style presentations in Operations and Production Management course (cf. [19]). At the very beginning of the 21st century, several commercial organizations like Responsive Learning Technologies, Marketplace Business Simulations and LINKS Simulations offered a few logistics and SCM educational games. Lewis and Maylor (2007) analyzed a number of operations management teaching and training games among which they recognized ten games related to logistics and supply chain [20]. Researchers of the Tippie College of Business, the University of Iowa, under the BizGames Project [21], developed a website with useful information on available games classified as supply chain management games, inventory and production games, vehicle routing games, facility location games, and lean and quality games, suitable for teaching in operations management-related courses. Cvetic and Vasiljevic (2012) have developed the database of 47 available logistics and SCM games that can be helpful for the selection of games according to the specific course requirements [10].

The logistics and SCM games are diverse in terms of topics, scope, type, number of players, utilization costs, etc. According to their scope, they can be classified from a microscopic orientation (such as some parts of a logistics system, such as a machine, transportation vehicle, etc.) to a macroscopic orientation concerning a total supply chain, based on [22]. The presence or absence of the supply chain related topics based on the Supply Chain Operations Reference (SCOR) model (cf. [23]) and the presence or absence of additional topics such as finance, marketing, sales and human resource management in the scope of a game can be determined. They are used to enhance awareness, comprehension or know-how of the environment being considered (according to Riis (1995) in [24]). The logistics and SCM games can be classified according to the type as non-computer and computer games, and more concretely, as manual, software, and online games. The distinction can also be made between single-user and multi-user games. In the case of multi-user games the group of players can have the same or different functionalities or roles [24] and often the minimal and/or maximal number of players is limited. In terms of costs offered logistics and SCM games are very diverse ranging from free games to expensive commercial games.

The logistics and SCM games are very useful because they can 'increase students' interest and improve the course outcomes' [25, p. 283]. They provide an enhanced learning experience as they help connect learning theory with real-world dynamic situations; they enhance students' active involvement in the learning process; increase students' motivation, and develop specific logistics and SCM knowledge and skills [11]. In addition, they promise more than enhanced learning experience, which Pasin and Giroux (2011) characterized as an 'enhanced reality', through an environment 'without real risks' in which nobody really suffers from poor decision-making; they also increase students' confidence level, help them to experience repeatedly the same and/or similar situations from real life, take a break in problem-solving, quickly get clear feedback on decisions made and simplify complex real-life situations [11].

In light of this, the main question is: 'How to select the most suitable games for courses in the field of logistics and SCM?' The conceptual model of operations management gaming was proposed by Lewis and Maylor (2007) [20] and it was adapted into the transformational model for operations and supply chain management games by Huang et al (2008) [8]. Huang et al (2008) [8] also proposed the framework for game integration into Introduction to Operations and SCM course. The results of the BizGames Project [21] and Cvetic and Vasiljevic

(2012) study [10] are valuable in terms of collecting and analyzing information on available logistics and SCM games, but there is still a need for further development of a comprehensive decision-making support tool for the selection of these games.

3. Research process

To enhance the teaching and learning processes in logistics and SCM courses, the need for improvement of the process of the selection of suitable logistics and SCM games was recognized. The research process was designed in the following five stages: (1) research question; (2) data collection and analysis; (3) design and development of a DST SLSCMG; (4) pilot application of a DST SLSCMG; and (5) dissemination. Here, the main research question was how to support the process of the selection of the most suitable games in logistics and SCM courses? The data on 55 identified logistics and SCM games have been collected mostly from the literature and internet sources (using search engines Google, Google Scholar and Amazon). The results of [21, 10] were very helpful in this stage. In some cases, additional demonstrations and analyses were incorporated, where possible, to remain unbiased. An attempt to distinguish the features of games was done and each game was determined according to particular topics, the type of a game, the number of players, the duration of a game, and the costs of using a game. In this regard, the special attention was put on finding data about the minimal number of players, the average duration of a game, the minimal duration of a game, the minimal institution's costs of using a game and the minimal student's costs of using a game, because, based on our experience, they can be of a key importance in the process of game selection. In the fourth stage the main components of DST SLSCMG for an introduction to logistics and SCM games, the selection of these games based on limitation criteria, and their assessment were designed, and this tool was developed in Microsoft Excel 2007. More information on the design of the DST SLSCMG is provided in the next section.

In the following stage, the DST SLSCMG was applied in Business Logistics and Supply Chain Management courses at the Faculty of Organizational Sciences (FOS), the University of Belgrade. The two limitation criteria related to the costs were established, which resulted in a reduced number of games for further assessment. This was followed by the use of the derived game suitability indicator based on which the final decisions regarding the selection of games were made. For each selected game, the Likert-type questionnaire was designed so that its statements could be used to determine the students' level of satisfaction with that game. Thus, the statements regarding how interesting it is, the ease of the use of a game, the learning benefits, better understanding of some phenomena, the importance and the complexities of some specific problems, and desire for more games like that one to be used in a further teaching process were the basis for a creation of a 'game satisfaction' composite variable for each game (Appendix A); these composite variables enable the comparison of the given games. Results were analyzed and compared with the SPSS statistics package (version 17.0). Finally, the DST SLSCMG is offered for free and its future development and dissemination is offered to future interested educators.

4. Design of the DST SLSCMG

The DST SLSCMG is intended primarily for educators interested in game-based enhancement of teaching in logistics and SCM courses. It may be used by a team of teachers, lecturers, teaching assistants and/or instructors of the courses for which the selection of suitable games is conducted. It should be noted that this decision-making tool does not give an assessment by itself. The DST SLSCMG is developed in Microsoft Excel 2007 using Visual Basic for Applications (VBA) (Fig. 1). The DST SLSCMG is available free of charge from the first author upon an email request (cvetic.biljana@fon.bg.ac.rs) and can be adapted according the specific needs of users.

The DST SLSCMG includes three main components for an overview of logistics and SCM games, selection of these games based on limitation criteria, and their assessment. The input-output relationships between these components are shown in Fig. 2. The idea for this kind of representation of relationships is based on [26]. From the Fig. 2, it is obvious that the educators' previous experience in using games and the course syllabus are an important input for making a decision which logistics and SCM games to use to meet course requirements.

The first component, Preliminary introduction to logistics and SCM games, enables the exploration of the database of 55 available logistics and SCM games which was created by modification and expansion of the database offered by [10]. The data for each game include: the name of a game; the author of a game; topics covered by key words; the presence or absence of supply chain related topics based on the SCOR model, i.e. a plan, source, make, delivery and return; the presence or absence of additional topics such as finance, marketing, sales and human resource management; specific topics; the type of a game (manual, software or online); the number of players; the minimal

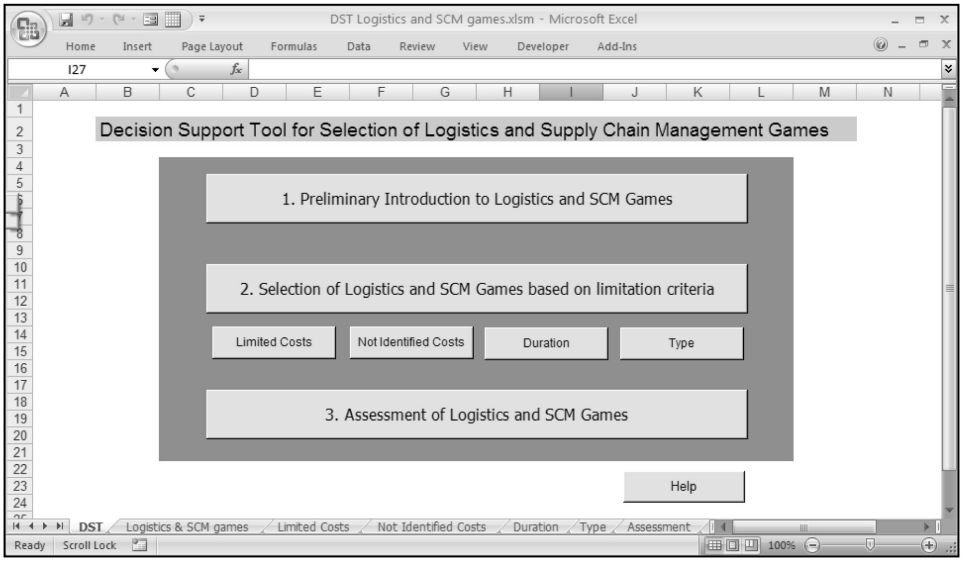


Fig. 1. Main screenshot of the Decision Support Tool for Selection of Logistics and Supply Chain Management Games (DST SLSCMG).

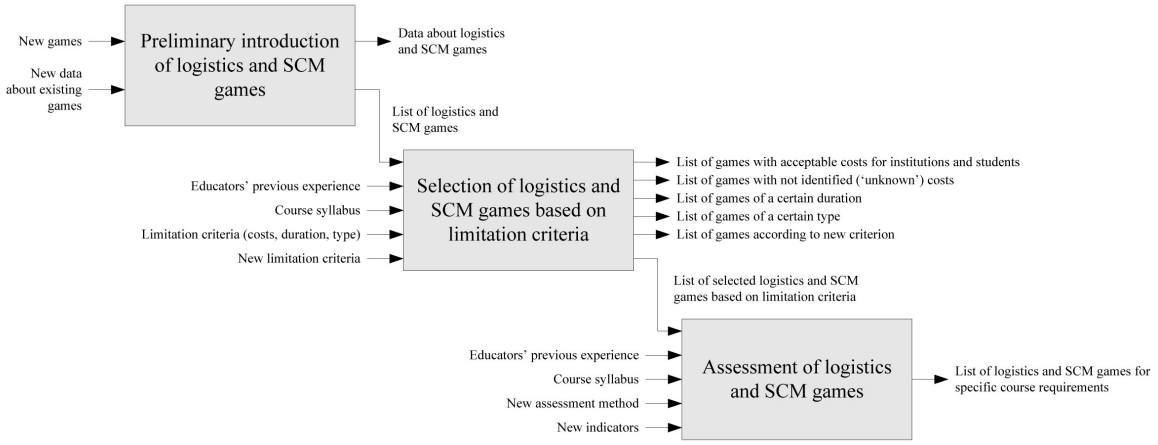


Fig. 2. Input-output relationships between the main components of the DST SLSCMG.

number of players; the average duration of a game; the minimal duration of a game; the minimal institution' costs for using a game; the minimal student's costs for using a game; the year when the game was first introduced, and a link to the game and/or additional data about it (cf. Fig. 3). The existing data in this database can be updated and new entries can be added. For example, for some games the cost of an institution and/or a student is still not identified and if the users of the DST SLSCMG find out this value, the data can be added to the database. Also, all data about games can be easily filtered by various criteria.

The second component, Selection of logistics and SCM games based on limitation criteria, enables extraction of games based on these criteria. The following four criteria can be used: the limited costs of using a game, the not identified ('unknown') costs of using a game, the duration of a game, and the type of a game. The use of limited cost criterion enables extraction of games with acceptable costs for institutions and students in dollars. The use of the option 'unknown' cost criterion enables extraction of games for which the costs are not identified. The use of duration criterion enables extraction of games based on the maximal acceptable game duration in hours. The use of type criterion enables extraction of manual, software or online games. The users of the DST SLSCMG can add and use new criteria for selection of logistics and SCM games.

The third component, Assessment of logistics and SCM games, enables support for assessment of game's suitability for the specific course requirements. The users of the DST SLSCMG should decide what the most appropriate assessment method for their need is, what indicators to use,

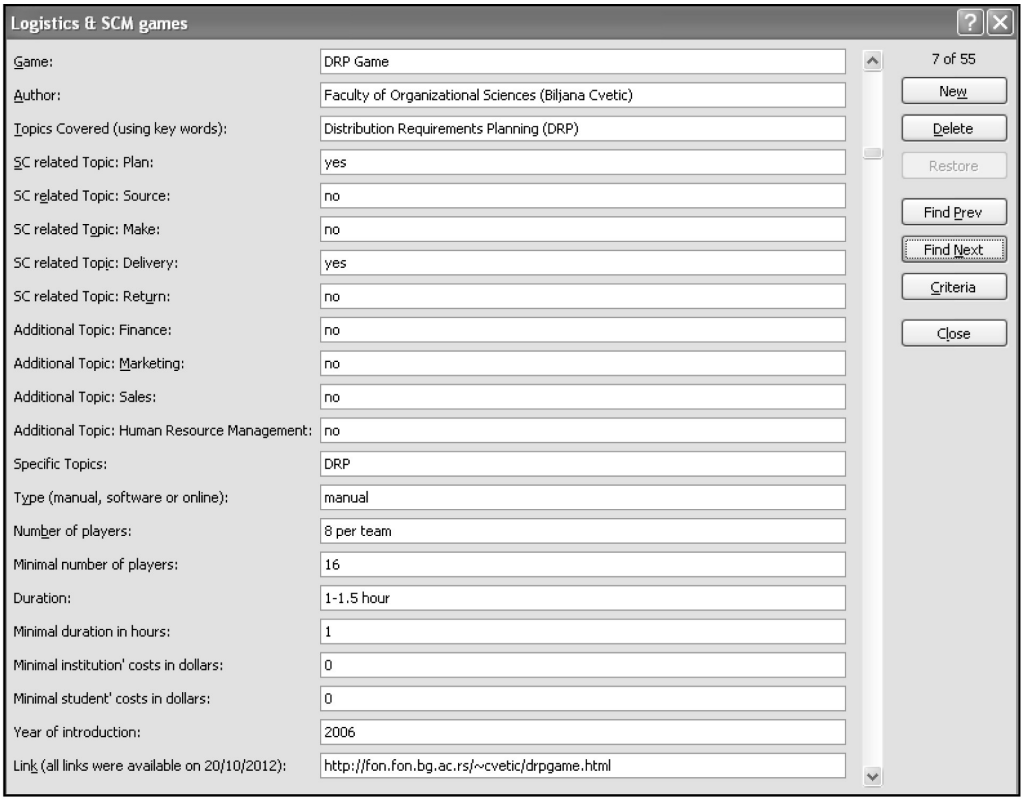


Fig. 3. Data window for one logistics and SCM game.

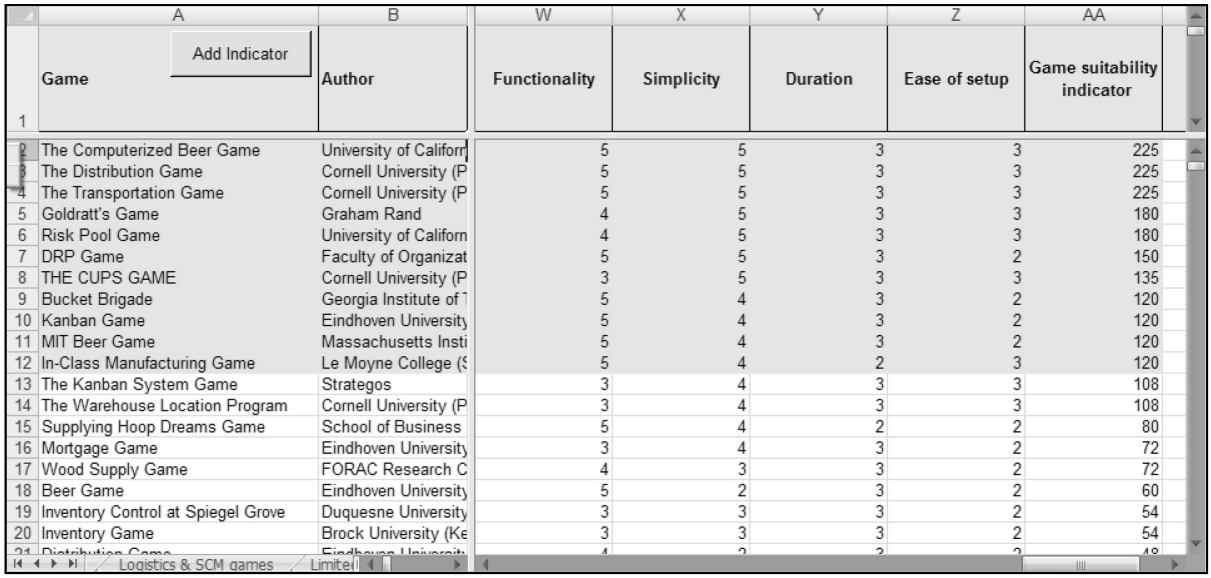
what type of scale to use for indicator assessment, if they plan to use a game's suitability-derived indicator, and like. For example, a user can decide to use the combined weight of functionality, simplicity, duration and ease of game setup.

5. Case study: Application of the DST SLSCMG

The DST SLSCMG has been applied at the FOS, University of Belgrade, for the selection of the most suitable logistics and SCM games to be used in combination with other teaching methods in the Business Logistics and Supply Chain Management courses. Here, it should be noted that the problem of the selection of the most suitable logistics and SCM games at the FOS had been previously solved by the custom-made selection procedure (cf. [10]).

The team first established the following criteria related to costs: the maximum affordable institution's costs are $250 and the maximum affordable student's cost is zero. These criteria are important because of the austerity in the Serbian academic environment and low living standard in general. The FOS mainly use the tools with an academic license (i.e. free for academic use). Furthermore, it is unrealistic to demand additional expenses from students. These limitation criteria were applied on the database of logistics and SCM games using the "Limited Costs" command button from the DST SLSCMG and a total of 27 games were extracted for further analysis.

In the next step, the team made a decision to use a derived game suitability indicator based on a combined weight of functionality, simplicity, duration and ease of setup, for the assessment of game's suitability for requirements of the two courses. Therefore, the assessment indicators were added in the "Assessment" sheet with following instructions in the third component of the DST SLSCMG. The assessment of the functionality was done on a five-point scale, from 1 (very poor) to 5 (very good); the simplicity on a five-point scale, from 1 (very hard) to 5 (very easy); the duration on a three-point scale, from 1 (too long) to 3 (appropriate), where 'too long' means more than 6 hours and 'appropriate' means up to 3 hours; and the ease of setup on a three-point scale, from 1 (hard) to 3 (easy). From this it follows that the maximum value of a derived game suitability indicator is 225. Then, for every game in the "Assessment" sheet the team assessed values of these indicators based on available data about games in the DST SLSCMG, their previous experience, additional data about games found on the internet and the demonstration of game, if possible. Finally, the team selected a total of 11 games with the value of the game suitability indicator above 112.5 for further consideration (Fig. 4).



	A	B	W	X	Y	Z	AA
1	Game (Add Indicator)	Author	Functionality	Simplicity	Duration	Ease of setup	Game suitability indicator
2	The Computerized Beer Game	University of Californ	5	5	3	3	225
3	The Distribution Game	Cornell University (P	5	5	3	3	225
4	The Transportation Game	Cornell University (P	5	5	3	3	225
5	Goldratt's Game	Graham Rand	4	5	3	3	180
6	Risk Pool Game	University of Californ	4	5	3	3	180
7	DRP Game	Faculty of Organizat	5	5	3	2	150
8	THE CUPS GAME	Cornell University (P	3	5	3	3	135
9	Bucket Brigade	Georgia Institute of	5	4	3	2	120
10	Kanban Game	Eindhoven University	5	4	3	2	120
11	MIT Beer Game	Massachusetts Insti	5	4	3	2	120
12	In-Class Manufacturing Game	Le Moyne College (	5	4	2	3	120
13	The Kanban System Game	Strategos	3	4	3	3	108
14	The Warehouse Location Program	Cornell University (P	3	4	3	3	108
15	Supplying Hoop Dreams Game	School of Business	5	4	2	2	80
16	Mortgage Game	Eindhoven University	3	4	3	2	72
17	Wood Supply Game	FORAC Research C	4	3	3	2	72
18	Beer Game	Eindhoven University	5	2	3	2	60
19	Inventory Control at Spiegel Grove	Duquesne University	3	3	3	2	54
20	Inventory Game	Brock University (Ke	3	3	3	2	54
21	Distribution Game	Eindhoven University	4	3	3	2	48

Fig. 4. Games selected on the basis of game suitability indicator with the help of the DST SLSCMG.

The team decided to use the Kanban Game (developed by Welters under the supervision of Van der Aalst [27]) as a supplement to lean logistics topic, the DRP Game (by Cvetic [28]) to support distribution channels and DRP topic and The Distribution Game (by Jackson and Muckstadt [29]) as a supplement to a short overview of SCM topic of Business Logistics course. The team also decided to use The Computerized Beer Game (by Kaminsky and Simchi-Levi [30]) as a supplement to coordination and bullwhip effect topic, the Risk Pool Game (by Kaminsky and Simchi-Levi [30]) as a supplement to a risk pooling in the supply chain topic and The Transportation Game (by Jackson and Muckstadt [31]) to support the topic of transportation and warehouse management in the Supply Chain Management course. The In-Class Manufacturing Game (by Ammar and Wright [32]) was not been selected because students acquire advanced material requirements planning (MRP) skills with the help of WinQSB software solution (module MRP) (by Chang [33]) in another course. There were some doubts which game to use: The Computerized Beer Game or the MIT Beer Game (by Li and Simchi-Levi [34]). The demonstration of these games in the computer laboratory environment showed that students' progress in understanding the 'bullwhip effect' was more difficult when they used the MIT Beer Game online, and students were suggested to use it on their own, if they want to try it. The Goldratt's Game (by Rand [35]) and the Bucket Brigade game (by Bartholdi III [36]) were left for some future consideration and the next generation of students.

6. Results of perceived satisfaction with selected games

The evaluation of selected games was conducted during the four semesters from 2011 to 2013 with the aim to assess the students' level of satisfaction with playing the games in the given two courses. A total of 58 (24 from one generation and 34 from another) completed students' questionnaires from the Business Logistics course and a total of 42 (25 from one generation and 17 from another) questionnaires from the Supply Chain Management course were considered in this study. Several completed questionnaires regarding the games were randomly excluded to obtain an equal number of students in each post-game evaluation in these courses. The number of respondents-students was small; limited to the number of students in the Operations Management program.

Two generations of students from both courses were asked to rate their satisfaction with certain games on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The composite variable was created for each game by summing the students' rating of the six statements (Appendix A) and the degree of internal consistency among these statements was tested with Cronbach's alpha. Cronbach's alpha greater than 0.7 was taken as acceptable according to [37, p. 231] and results indicated that each composite variable was internally reliable (Table 1 and 2). The Shapiro—Wilk test was used for testing the normality of the distributions of the composite variables (Table 1 and 2). Since the results of the Shapiro–Wilk test showed that the certain composite variables were not nor-

Table 1. Summary of constructs for three games in the Business Logistics course

Composite variable	Population[a]	Mean[b]	SD	Cronbach's alpha	Shapiro-Wilk W test
Kanban Game satisfaction	I	23.67	4.54	0.799	0.922
	II	20.76	5.92	0.809	0.956
DRP Game satisfaction	I	28.79	1.62	0.744	0.762**
	II	28.65	1.56	0.756	0.826**
Distribution Game satisfaction	I	26.67	3.35	0.773	0.857**
	II	26.71	2.95	0.778	0.887**

[a] I—the first population of students (N = 24), II—the second population of students (N = 34).
[b] From minimum possible mean of 6 to maximum possible mean of 30.
* p<0.05; ** p<0.01.

Table 2. Summary of constructs for three games in the Supply Chain Management course

Composite variable	Population[a]	Mean[b]	SD	Cronbach's alpha	Shapiro-Wilk W test
Computerized Beer Game satisfaction	I	23.20	4.94	0.795	0.880**
	II	24.20	3.45	0.768	0.919*
Risk Pool Game satisfaction	I	26.80	2.43	0.778	0.936
	II	22.53	5.86	0.804	0.811**
Transportation Game satisfaction	I	26.76	2.83	0.782	0.891*
	II	20.59	4.26	0.786	0.965

[a] I—the first population of students (N = 25), II—the second population of students (N = 17).
[b] from minimum possible mean of 6 to maximum possible mean of 30.
* p<0.05; ** p<0.01.

mally distributed, the differences between the level of satisfaction of students with the games in both courses were tested with the non-parametric Friedman test and in the case of significant differences a post-hoc Wilcoxon signed-rank test was used.

In the Business Logistics course results from the first observed population of students showed statistically significant differences between the 'Kanban Game satisfaction', 'DRP Game satisfaction' and the 'Distribution Game satisfaction' according to Friedman test (χ^2 = 15.060, df = 2, p = 0.001). The post-hoc analysis with Wilcoxon signed-rank test was further used with a Bonferroni correction coefficient (p = 0.017). The decision about the relevant statistics was made according to [38], i.e. if the number of pairs minus ties (N) is 15 or less, the relevant statistics is the sum of positive ranks (T^+ value), otherwise the z value will be used. The satisfaction with the DRP Game was significantly higher than with the Kanban Game (Wilcoxon signed-rank test: N = 22, z = –3.688, p<0.001, with a large effect size r = 0.53). Positive ranks (19) far more outnumbered negative ranks (3). The satisfaction with the Distribution Game was significantly higher than with the Kanban Game (Wilcoxon signed-rank test: N = 23, z = –2.469, p = 0.007, with a medium effect size r = 0.35). Positive ranks (16) outnumbered negative ranks (7). The satisfaction with the Distribution Game was significantly lower than with the DRP Game (Wilcoxon signed-rank test: N = 15, T^+ = 17.50, p = 0.01). Negative ranks (12) outnumbered positive ranks (3).

Results from the second population of students enrolled in the Business Logistics course also showed statistically significant differences between the 'Kanban Game satisfaction', 'DRP Game satisfaction' and the 'Distribution Game satisfaction' (Friedman test: χ^2 = 34.346, df = 2, p<0.001). The satisfaction with the DRP Game was significantly higher than with the Kanban Game (Wilcoxon signed-rank test: N = 32, z = –4.814, p<0.001, with a large effect size r = 0.58). Positive ranks (30) far more outnumbered negative ranks (2). The satisfaction with the Distribution Game was significantly higher than with the Kanban Game (Wilcoxon signed-rank test: N = 33, z = –3.989, p<0.001, with a medium effect size r = 0.48). Positive ranks (27) far more outnumbered negative ranks (6). The satisfaction with the Distribution Game was significantly lower than with the DRP Game (Wilcoxon signed-rank test: N = 28, z = –3.155, p = 0.001, with a medium effect size r = 0.38). Negative ranks (22) outnumbered positive ranks (6). These results confirmed the results obtained for the previous generation of students.

In the Supply Chain Management course significant differences were not found between the 'Computerized Beer Game satisfaction', the 'Risk Pool Game satisfaction' and the 'Transportation Game satisfaction' based on assumed significance level of p = 0.03. Results of Friedman's test for these three

games rated by the first population of students were $\chi^2 = 6.506$, df = 2, p = 0.039; and second population were $\chi^2 = 2.952$, df = 2, p = 0.229.

7. Discussion of results

A new decision-making support tool has been proposed to help educators assess both well-known and less-known available logistics and SCM games and select the most suitable ones for their needs. This tool enables educators to establish and conduct a formal process of selection of logistics and SCM games with ease. The DST SLSCMG includes three main components which enable the overview of 55 logistics and SCM games, using existing and new criteria for the selection of these games and their final assessment by the educators. For each game a number of useful data are given. This tool is available free of charge, and more importantly, the existing data about games can be updated, new criteria of selection and assessment indicators can be added, a help file is provided, and all VBA macros of this tool are unprotected and can be extended.

The games have been used for active support in the Business Logistics and Supply Chain Management courses at the FOS for a long time. Pursuing the idea from [10], the DST SLSCMG has been designed and applied, resulting in the selection of six games for these courses. Results of perceived satisfaction with logistics and SCM games confirmed that students were very satisfied with the combination of games selected with the help of the DST SLSCMG. In the Business Logistics course the students were particularly satisfied with the games. However their satisfaction with the DRP Game was statistically significantly higher than their satisfaction with the Kanban Game and the Distribution Game. Nevertheless, these results should be taken with caution because the students knew the origin of the DRP Game and they were probably subjective in awarding scores to this game. In the Supply Chain Management course, the students were statistically equally satisfied with the Computerized Beer Game, the Risk Pool Game, and the Transportation Game. This was interesting because the perceived satisfaction with the Beer Game, which is the most famous logistics and SCM game, was not significantly higher than satisfaction with the other two games. It is possible that the results will be different for more respondents-students. Also, the instructors were surprised with the results of evaluation mostly because of the following reasons: (1) the Distribution Game and the Transportation Game were amusing for students even though these games originate from the 1990s; (2) the Kanban Game was very well rated although students experienced some difficulties in running this game, i.e. in connecting the Java environment and CPN Tools; (3) the Risk Pool Game got high scores although some students expressed the opinion that they would like to play this game without suggested values for players; (4) in general, the computer games got high scores from students although they might meet compatibility problem when playing games outside the FOS laboratory.

The presented case study is an example of how logistics and SCM games can be selected with the help of a decision support tool and used by educators who do not have a high budget to purchase a game and do not have the possibility to ask the students to pay for educational games. This limitation was included in the selection process and certainly led to a need to cut out some very useful games. The educators who work in an educational environment without cost restrictions for using games will have a much greater choice for selection of these games with the help of the DST SLSCMG.

The positive results and experiences from this study encourage further application of the DST SLSCMG. In future, it will be valuable to develop taxonomy for logistics and SCM games and, based on that, improve the database of games, which is an important component of the DST SLSCMG. The assessments of game's suitability are also very important and require further consideration. In future, the intention is to continue the evaluation of the use of games with the improved Likert-type questionnaires and to provide the more comprehensive comparison of results between different generations of students. Also, the use of pre-game questionnaires will be considered with the aim to provide a basis for testing whether students really learn something from logistics and SCM games.

8. Conclusion

The schools of engineering are faced with the challenge to introduce or improve courses and even study programs related to the field of logistics and supply chain management. The use of logistics and SCM games was recognized as a helpful and enjoyable supplement to other teaching methods. Since the early 1960s a number of logistics and SCM educational games have been developed, which are diverse in terms of topics, scope, type, number of players, utilization costs, etc. One of the main problems, which is highlighted in this study, is where to find the data about available logistics and SCM games and how to select the most suitable games for logistics and SCM related courses.

The main contribution of this study can be summarized as the design and development of a new original decision-making support tool for the

selection of logistics and SCM games (DST SLSCMG). The DST SLSCMG is offered here to help interested engineering and management educators to select one or a suite of games by using different selection criteria and assessment methods to suit specific requirements of courses. The DST SLSCMG's database includes a number of useful data for 55 identified logistics and SCM games and these data can be updated with ease. This tool involves a help file and comes with all unprotected VBA macros which enables its potential extension. More of that, this version of the DST SLSCMG is available free of charge. The DST SLSCMG is applied at an engineering school for the selection of the most suitable games for two courses and the perceived students' satisfaction results of the evaluation of these games showed that two generations of students were very satisfied with the selected games.

The presented study and generalization of data display some limitations due to the small populations of students and only two courses considered. In addition, the limitation is in the fact that examinees in our study are taken as a relatively homogenous group and the impact of the specific needs and motives were not taken into account. In order to further verify our findings and make them more widely applicable, in our future work we intend to examine influence of different logistics and SCM games on students' achievements. However, the problem of logistics and SCM games selection still remains open, and it is hoped that this study will be provocative enough for future research.

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Appendix A. Definition of composite variable 'game satisfaction'

Composite variable	Composite definition
Game satisfaction (Kanban Game, DRP Game, Distribution Game, Computerized Beer Game, Risk Pool Game, Transportation Game)	*Game* satisfaction was formed from the sum of scores obtained for the following statements: • '(*Solving the particular*) management (*problem*) with the help of the *Game* is interesting'; • 'Using the *Game* is easy'; • 'Playing the *Game* helped me learn something I had not previously known'; • 'I understand better the (*particular phenomena*) after playing the *Game*'; • 'I understand better the importance and the complexities of (*particular*) problem in practice'; and • 'I would like more games like this *Game* to be used in teaching processes'.

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