Assessing Serious Games Within Purchasing and Supply Management Education: An In-class Experiment

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Abstract:
Purchasing and supply management (PSM) is evolving with the introduction of new technologies. To benefit from purchasing activities and technological advancement, purchasing professionals need specific skills (Bals et al., 2019). Therefore, current study programs need to be adjusted, and educational methods need to be found (Pekkanen et al., 2020). An example of these educational methods is Serious games as the beer distribution game within the Supply Chain Management (SCM) context (Forrester, 1961). However, available games are not focused on purchasing. Thus, an online purchasing game has been developed, focusing on cost-reduction techniques and supplier relationship management. In the game, the students manage an organisation's purchasing department and progress from an operative buyer towards a chief purchasing officer. Since this game is a substitute for the existing traditional lectures, the usefulness of this is tested in a group comparison experiment. A group following the traditional lectures (N=66) was compared to the group of students learning through serious game lectures (N=105). For data collection, self-rated surveys, pre-and post-survey, and the exam scores have been analysed. Based on the experimental methodology applied, it has been observed that students who played the game, scored significantly higher in the exam. Further, the design of the game was evaluated based on various criteria, such as competitive and collaborative elements, game design, and understandability. It has been shown that serious games are useful to deepen the understanding of purchasing and develop purchasing skills.

Keywords: *Purchasing and Supply Management, Education, Serious Games, Skills, Experiment*

1. Introduction: Educating PSM skills with the use of a Serious Game

Recent research and publications in the purchasing and supply management (PSM) field highlighted that purchasers' skills change for three major reasons. First, the field developed from an operative towards a strategic function requiring enhanced skills. Second, contextual changes shifted the scope of purchasing, for instance, on innovation and sustainability within the supply chain. Third, the working environment of purchasers is changing due to the implementation of new technologies (Delke et al., 2020). These changes require advanced, specific, and diverse skills for purchasing activities. Giunipero and Pearcy (2000), Tassabehji and Moorhouse (2008), and recent publications addressed the changing skill requirements (Bals et al., 2019). However, only limited research is available on how to educate these skills. Research scholars emphasize the importance and need for sophisticated educational methods and programs (Giunipero and Pearcy, 2000, Bals et al., 2019, Pekkanen et al., 2020). The challenge will be to educate students in the study programs and practitioners currently in the field. Thus, adequate didactical methods will be needed where the selection and application of educational methods within PSM is the core of the research presented below. The objective of this research is to find useful educational methods to train future purchasers. Therefore, a serious game has been developed and implemented within a higher education purchasing oriented study program intending to answer the research question: *How useful are serious games to educate PSM skills?*

A comparison study, organised as an experiment, has been conducted to assess the usefulness of serious games. The comparison study continued for over two years and involved a total of 106 students playing the game. The test groups' learning experience and performance were compared to the 66 students who followed

three traditional lectures addressing the same learning objectives. Within these "traditional" lectures, students had the opportunity to interrupt the teacher for questions. A pre-and post-survey study has been conducted, and the learning outcome has been assessed based on a 20 questions multiple-choice exam. The study's outcome shows that the developed serious game is a useful method to educate future purchasing professionals, where students playing the game as exam preparation score significantly higher than students following the traditional lectures. Further, the survey study provides insights into how students perceive serious games within PSM education.

2. Theoretical background: Building on gamification to design a PSM game

2.1 Gamification and Serious Game literature review

Researchers are currently differentiating between gamification and serious games. On the one hand, gamification has been described as *"the use of game design elements in a non-game context"* (Deterding et al., 2011), *"creating a gameful experience"* (Hamari et al., 2014), or *"the process of making activities more game-like"* (Werbach, 2014). Serious games can be defined as *"any form of interactive computer-based game software for one or multiple players to be used on any platform, and that has been developed with the intention to be more than entertainment"* (Ritterfeld et al., 2009). These games are *"a system in which players engage in an artificial conflict, defined by rules, that results in a qualifiable outcome"* (Salen et al., 2004). This paper aims to increase the students' knowledge acquisition and skill by using a serious game that allows in-depth learning of the addressed content (Hamari et al., 2014). To develop and assess the game, the gamification and serious game literature has been reviewed. Based on the work of Wilson et al. (2009), and that of Bedwell et al. (2012), a list of 19 game attributes that contribute to learning outcomes is consolidate. These include adoption, assessment, challenge, conflict, control, fantasy, interaction (equipment), interaction (interpersonal), interaction (social), language/communication, location, mystery, pieces or player, progress, surprise, representation, rules/goals, safety, and sensory stimuli. Previous literature shows that serious games help improve student motivation and engagement and achieve learning objectives. Still, limited research addresses the connection between specific game attributes and learning outcomes. To create a meaningful learning experience, the student should have a high engagement level with the learning content, which multiple components can achieve. However, it is difficult to measure performance and outcome measures for retention, satisfaction, attendance, engagement, motivation, and socialisation (Mora et al., 2017).

Developing a serious game needs to benefit the specific stakeholder focusing on domain-specific knowledge (van den Berg et al., 2017, Prensky, 2001). Further, the goal and objectives of the game need to be clear and understandable (Mora et al., 2017, Blunt, 2007, William et al., 2018). By linking the game content and its objectives, it is essential to have the right level of abstraction of the used concepts and reality (Hosseini and Haddara, 2019, Brauner et al., 2016). Thus, the game should represent a simplification of the PSM environment in reality without being too complex. Often, the game's complexity increases while the student progresses in the game, i.e., between different playing rounds (Westrom and Shaban, 1992). While playing the game, adequate rules and level of complexity should continue, such that the students can observe the impact of their decisions (Aguiar and Nakano, 2017, William et al., 2018). One central component for a serious game to achieve high student engagement is the enjoyment level of the student-player (Aguiar and Nakano, 2017, Mora et al., 2017). When the students enjoy playing the game, they are more likely to continue and achieve the best possible results. Therefore, serious games benefit from appealing aesthetics via the user interface and gameplay (Brauner et al., 2016, Hosseini and Haddara, 2019, Aguiar and Nakano, 2017). Further, the enjoyment and engagement of the students increase with the presence of the elements that support competition, rewards, and rankings (William et al., 2018). The interaction between the different learners is highly important, which can be achieved by competition and collaboration between the players (Gari et al., 2018, Muangsrinoon and Boonbrahm, 2019). To help the student's learning, addition performance indicators in the game provide instantaneous feedback. Thus, multiple opportunities for feedback should be available to allow the student to reflect on game activities and their decisions (Brauner et al., 2016, Gari et al., 2018).

2.2 Skills and competencies in PSM

The PSM-skills literature is a tributary to Larry Giunipero and co-authors' seminal work. The scientific reports for the longitudinal research of the Centre of Advanced Purchasing Studies in 1993 and 2000 (Kolchin and

Giunipero, 1993, Giunipero and Pearcy, 2000) resulted in the study of Giunipero and Pearcy (2000) that summarises the findings in the field in the 20th century providing a PSM skills taxonomy. Next, the research of Tassabehji and Moorhouse (2008) concludes that a purchaser needs to master a complete set of skills, which include Technical Skills, Interpersonal Skills, Internal Enterprise Skills, External Enterprise Skills, and Strategic Business Skills (Tassabehji and Moorhouse, 2008). Recently, Bals et al. (2019), extended the body of knowledge with an extensive literature review combined with interview studies to conclude the skills needed by current and future professionals. Next, the work of Delke et al. (2020) and Stek and Schiele (2020) extended the list, identifying specific skills needed to achieve success within PSM. The available list of skills was evaluated, and a list of PSM skills needed was abstracted (see list within the results Table 5). Here, the focus was on needed "hard skill" within the field (Andrews and Higson, 2008). These PSM skills were addressed within the later described game design and experiment as the course's learning objectives.

3. Methodology: Between groups comparison experiment

3.1 Two groups experiment

This research uses an experimental study approach to identify causality and identify mechanisms where other data sources fail to provide insights (Charness et al., 2012, Chatterji et al., 2016). The experimental research design helps to understand the role and benefits of the developed serious game in educating PSM skills. Various educational studies use a pre-experiential design, where a group is exposed to an experimental variable or an event (X), and later the outcome is measured based on observation or measurement (O) (Campbell and Stanley, 2015, Hacking, 1984). This research applies an O1-X-O2 experiment research design, which includes a measure of knowledge before (O1) and a measure of knowledge after (O2) exposing the group to the experimental variable or event (X) (Campbell and Stanley, 2015). Therefore, the one-group pre-test–the post-test design was conducted based on a survey. Further, to compare how well students learned from the game compared to the traditional lectures, a control group design was utilized, resulting in a between-subject design (Charness et al., 2012). Since there was no control group available within the same bachelor program, the identical learning objectives were taught using a traditional lecturing approach in the master's program. The aspect that is beneficial for this study was that both groups are comparable in their pre-knowledge on purchasing related topics, owing to a lack of purchasing related courses in their previous study programs or education. The study was conducted across two academic years (2019-2021), resulting in two data collection phases of the experimental and control group (see Figure 1). In the study year 2020-2021, the data collection was challenged by the COVID-19 pandemic. However, it was possible to organize the courses similar to previous years, organizing the control groups lectures online, and the game sessions as an offline tutorial on campus. Further, the assessment of the learning outcome, here the multiple-choice questions, were not published. The data collection was similar in all years, confirmed by the similar assessment scores between the years (see Table 6), finding no significant difference.

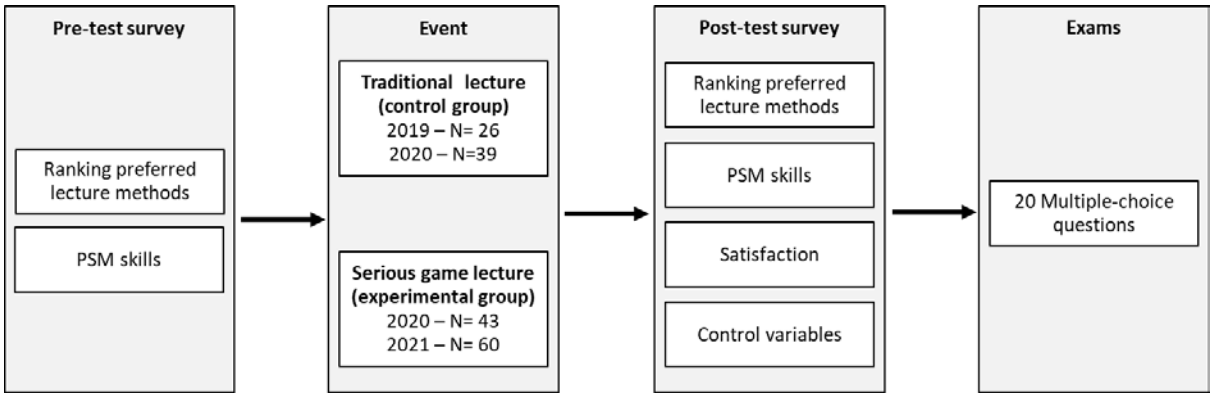

Figure 1: Experiment Setup

3.2 Lecture content and game design

The developed game is an online multiplayer game that classifies as a simulation game and is used as a case study (Wilson et al., 2009). Since the game addresses the PSM context, characterised by marked dynamics, it was important to find a game design that allows interaction between the different teams (players). These interactions include the influence of one team's decision on the game situation of other teams, for example, an increasing price when the demand for components is high. In the game, students take the role of purchasing manager of a middle-sized brewery. Students play the game in teams of 2-3 players. The teams were randomly assigned by the teachers and did not change during the game. The game course is organised into four lectures, wherein each lecture, students will play one business year of the brewery (four years in total). The first lecture takes about 45 minutes to introduce the game, organises the student teams, and playing the first round of the game to get to know the game environment. Next, the three modules (1) Supplier Satisfaction; (2) Cost-optimisation; and (3) Innovation Management follow (see Figure 2). Each module is organised in three phases, following the input-process-outcome serious game design model of Garris et al. (2002). First, a micro lecture is held by the teacher introducing the instructional content and game characteristics of the discussed module. Next, students play for 45 minutes the game, followed by a reflection and discussion (see Figure 2). Within the first phase, the input, the teacher introduces the instructional content as a micro lecture, where the teacher provides a short introduction on the discussed topics within the modules and introduces where these topics are embedded within the game. The second phase addresses the process of the game where students will play the game within an online environment. During the playtime, students will analyse the purchasing situation of the firm, take decisions within their purchasing department, observe the outcome of their decisions, reflect on their decisions, and improve their plan for the next round. The students' decisions include requesting and preparing to solicit offers to order components from suppliers, cost pricing to market their products, and several investment projects to launch cost-saving techniques or improving supplier satisfaction. All decisions are managed within the online game environment and will be progressed by the teacher automatically. As the game progresses, the students need to compete against each other for scarce resources in an increasingly complex supply market, including an element of surprise. The goal is to use a consistent purchasing strategy, fulfil the need for products, and reach a higher profit. The players who fulfil these goals better win the game. Therefore, the game provides direct feedback on how their decisions impact their game performance. Here, students see how decisions affect their profit margin or improve their supplier satisfaction. To increase feedback to the students, within phase three, the output, students discuss with their teacher in-class what is happening within the game, providing structure to the students' reflection. To increase competition within the game, students can partly see the decisions taken by other teams. These presented decisions include those decisions which would be transparent within a real-life market situation, increasing the level of reality of the game. Additionally, the game provides a ranking and performance dashboard. These performance indicators include, for example, the attained saving, profit, supplier satisfaction score, and selected suppliers of all groups. Within this dashboard, the specific decisions taken by other groups are not visible. Only a summary of the groups' decisions is presented. Further, the game uses collaborative elements to increase the interaction between teams. These collaborative elements include purchasing related decisions, which students' teams can take together. To make use of these collaborative decisions, the students must find teams willing to cooperate on projects within the game. These projects could, for example, include a collaborative sourcing strategy, bundling the purchasing volume of two teams to reduce purchasing costs. After playing the game for four years, the winning team is announced, and together with the teacher, discussing the used tactics in class. This debriefing of the game and reflection on the learning objectives is essential for the learning outcome.

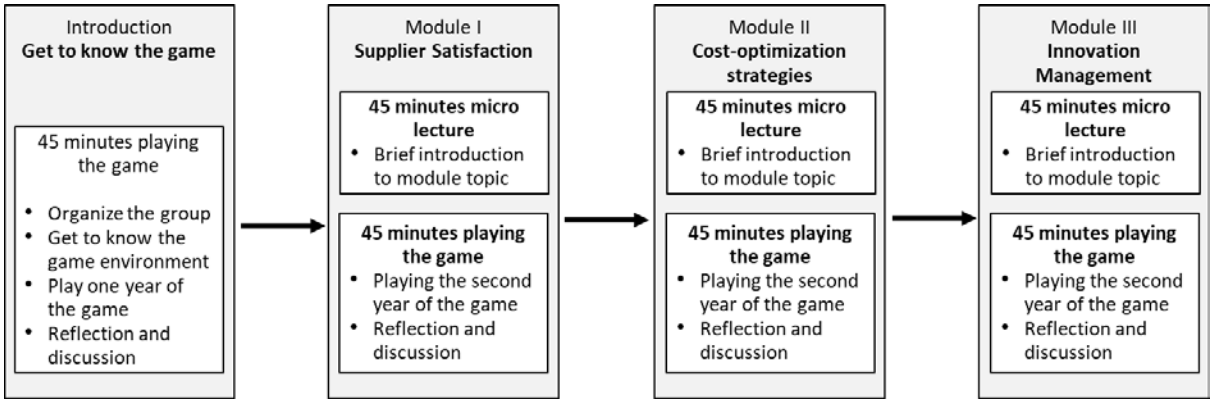

Figure 2: The serious game process

3.3 Sample characteristics

Within this research, the data is collected for the two experimental and two control groups at three scheduled times: (1) the pre-survey, (2) the post-survey, and (3) a 20 questions multiple-choice exam. 168 students participated experiment voluntarily and are provided with an opportunity to exit the data collection at any moment. Furthermore, the students were informed that overall group scores are used for scientific research, where collected data will be treated anonymously and cannot be traced back to individual persons. The sample characteristics are presented in Table 1. Only students with the same level of knowledge of the PSM field were selected to allow group comparison. Given that both programs are familiar to the researchers, it can be assured that they might not have addressed PSM related topics in their study programs. Before joining the lecture or game, their level of knowledge of PSM-related topics was assessed based on a self-assessment survey.

Table 1: Sample characteristics

Variable	Item	Serious Game ("experimental group")	Classic lecture ("control group")
Student numbers	N	103	65
Age	Average Age	22.55	25.02
Gender	Male	66	43
	Female	37	21
	Diverse	0	1
Nationality	Netherlands	72	56
	Germany	15	3
	Other	16	6
Highest completed educational level	High school or Secondary school	97	0
	Bachelor University	5	41
	Bachelor University of Applied Sciences	1	21
	Other	0	3
Currently enrolled study	Bachelor International Business Administration	85	0
	Master Business Administration	2	15
	Master Industrial Engineering and Management	0	44
	University level other	16	6

3.4 Data collection and analysis

To assess the difference between O1 and O2, a Paired-Samples or Dependent t-test with the Confidence Interval (CI) percentage at 95% is used (Field, 2018). The students answered the pre-survey before the first lecture and the post-survey at the end of the course (see Figure 1). The survey results were collected using the Qualtrics online survey software, where students provided their student numbers to match their pre-and post-survey results. Further, the multiple-choice exams were hosted offline on paper at the university. Post-data collection, the 'mean' results from subtracting the different items' outcomes in the post-survey from the pre-survey were calculated. Within the pre-survey, the students rated their preferred method of learning and assessed their purchasing competencies. The post-survey results addressed their preferred way of learning, their purchasing competencies, and an evaluation of the game and lectures. Here, the students' preferred way

of teaching was limited to the teaching methods used at the case university. Further, the competencies were assessed based on the survey design used by Stek and Schiele (2020). Also, the game attributes and elements were addressed based on the presented literature review above, including gamification elements (Hamari et al., 2014) and serious game attributes (Bedwell et al., 2012). Last, the variables addressing students' engagement, motivation, and energy level were measured according to Hamari et al. (2016), Caruana et al. (2016), and Welbourne et al. (2005). The competence level was measured on a 5-point-Likert scale from "no competence" to "training others in this competence". Further, control variables and the students' perception were measured on a 5-point-Likert scale from "fully disagree" to "fully agree". Moreover, Cohen's d effect sizes are calculated. The effect size are considered to be 'small' (.2<d<.5); 'medium' (.5<d<.8); or 'large' (.8<d<1.2) (Cohen, 1988).

4. Results: The game design is well-made and a high learning outcome was achieved

4.1 Students' game evaluation

Before playing the game, the preferred learning method was interactive lectures (mean = 3.10). The interactive lecture involves a high level of interaction between the students and the teacher, following a student-centred learning approach. After playing the game, serious games were preferred with a mean value of 3.04, which corresponds to a significant increase compared to the mean value of 3.97 before playing the game (see Table 2). This result shows that students were highly satisfied with the game and find it useful to enhance their PSM competencies. All nine lecturing methods are used at the case university, where traditional lectures are the dominant educational methods, and serious games are used more frequently in recent years. Additionally, the university largely utilises group work within the study program, which is also part of the developed serious game.

Table 2: Ranking of the preferred lecture methods

Learning method	Pre-survey*	Post-survey*	Mean difference	Significance (2-tailed)
Interactive lectures	3.10	3.16	0.058	0.780
Serious games	3.97	3.04	**-0.932**	**0.000**
Case-based learning	4.18	4.78	0.592	0.027
Studying lecture slides	4.63	4.73	0.097	0.669
Instructional videos	4.89	4.89	0.000	1.000
Traditional lectures	5.00	5.13	0.126	0.611
Group assignments	5.95	6.37	0.417	0.114
Individual assignments	6.31	6.33	0.019	0.942
Studying from books	6.96	6.58	-0.379	0.070

*Ranking scale from 1-9 (1=highly preferred to 9=less preferred); N=103

After playing the game, students rated their satisfaction level of playing the game and their engagement within the sessions. The questions asked were related to the above-described attributes, which help in developing a serious game. The first set of variables addressed the meaningfulness of the game for the learner, addressing the domain-specific knowledge and the perceived usefulness of the game for the student to learn (see Table 3). Results show that the game is a useful addition to the existing courses and study program, where students are satisfied to have played the game. Further, the students assessed that the game is a valuable addition to the traditional lectures, where the game helped retain the knowledge learned. Lastly, the students anticipated that the game help to develop PSM skills, which was later tested using the multiple-choice exam scores.

Table 3: Testing the satisfaction and engagement level of students playing

Variable	Mean*	Std. Deviation
Satisfied with having used the game	4.12	0.548
The right thing that the game was included in the course	4.02	0.727
Not happy to use the game in the course	1.84 (4.16)**	0.883
Improved study performance	3.56	0.848
Improved understanding of PSM	4.01	0.634
Enhanced effectiveness in the study of PSM	3.81	0.728

Made it easier to develop PSM skills	3.80	0.784
Useful for addressing PSM-related issues	3.88	0.783
A valuable addition to the traditional lectures	4.17	0.687
Helped retain the knowledge learned in the course	3.93	0.675
Showed a clear learning goal	4.19	0.672
High level of involvement	4.10	0.650

*5-point-Likert Scale (1=Strongly disagree; 2=Disagree; 3=Nether/Undecided; 4=Agree; and 5=Strongly agree); **reverse coding; N=103

As previously mentioned, the game was tested according to variables related to gamification principles and techniques that make a good serious game. One essential variable is the adequate number of rules and the right level of complexity, allowing the student to understand and use the game. Further, the appealing aesthetics via user interface and gameplay helped to improve the usability of the game. The evaluation outcome shows that the developed game is easy to use (see Table 4). Further, the competitive and collaborative elements were tested in detail since these elements help to create a game with high attendance, motivation, and engagement level of the students. High competition between the teams reflects the highly competitive PSM working environment. In this case, the game provided various ranking dashboards, for instance, the achieved profit, various performance measures, and direct visibility on decisions taken by other teams, e.g., the chosen suppliers or strategies. Lastly, the students collaborated with other teams, which improved interaction between them. Here, students could organise cost-reduction workshops together or collaboratively source products from one supplier. This element was especially useful to improve socialisation and engagement.

Table 4: Testing serious games attributes and gamification principles

Variable	**Mean***	**Std. Deviation**
Learning to use the game was easy	3.83	0.793
The game was easy to use	3.81	0.793
Easy to get the game to do what the student wants	3.71	0.824
Easy to become skilful at using the game	3.61	0.757
The interfacing was clear and understandable	3.86	0.687
The game environment felt competitive	3.96	0.670
Competitiveness is what the student enjoyed	4.00	0.642
Found no competitive elements	1.88 (4.12)*	0.855
The competitive elements improve game experience	3.83	0.643
Competitive elements helped learning experience	3.74	0.727
Collaboration is what the student enjoyed	3.75	0.801
Found no collaborative elements	1.77 (4.23)*	0.795
The collaborative elements improve game experience	3.78	0.641
Collaborative elements helped learning experience	3.76	0.678
The game was fun	3.97	0.720
Engaged with other students	4.06	0.712
Enjoyment of the game	4.08	0.652
Possibility for feedback	3.97	0.602

*5-point-Likert Scale; *reverse coding; N=103

4.2 Increased PSM-related skills

This serious game was designed to increase specific PSM skills. The skills addressed are based on an in-depth literature review of current and future purchasing competencies. To test the learning outcome, the difference between pre-and post-test was calculated, and a Paired-Samples t-test was performed. Further, Cohen's d effect sizes were calculated, observing a large effect for five skills (see Table 5). These skills are the game's main objectives, where students have to prepare a solicit offer every round and search for suppliers to fulfil their component demand. Further, the supplier development skills increased significantly, owing to the multiple decisions by the students that helped improve the suppliers' performance or improve the relationships with suppliers. Striking is the large effect size for the strategic business partner skills with

suppliers and competitors. The previously mentioned competitive and collaborative elements of the game may provide a rationale. Besides, a medium effect size is observed for ten further addressed PSM skills. These skills are included within the different modules of the game and the micro-lectures. For example, students learn different cost-reduction techniques and apply them within the game. The direct application of the learned techniques in the game helped knowledge retainment. Also, 13 skills were found, which increased but achieved a low Cohen's d value. These skills were mentioned during the short micro lecture but were under representative within the game.

Table 5: Difference between pre-and post-survey

PSM skills	Pre-survey*	Post-survey*	Mean difference	Significance (2-tailed)	Cohen's d
Prepare solicit offers	**1.63**	**2.40**	**0.77**	**0.000**	**1.163**
Global sourcing / supplier acquisition	**1.81**	**2.48**	**0.67**	**0.000**	**0.860**
Supplier development	**1.85**	**2.50**	**0.65**	**0.000**	**0.853**
Strategic business partner (supplier)	**2.03**	**2.67**	**0.64**	**0.000**	**0.851**
Strategic business partner (competitor)	**1.89**	**2.50**	**0.61**	**0.000**	**0.835**
Supplier relationship management	**2.06**	**2.64**	**0.58**	**0.000**	**0.775**
Supply market analysis	**2.03**	**2.54**	**0.51**	**0.000**	**0.719**
Evaluate offers & supplier selection	**2.12**	**2.59**	**0.48**	**0.000**	**0.710**
Cost reduction techniques	**2.16**	**2.56**	**0.41**	**0.000**	**0.640**
Negotiation the specific terms	**1.98**	**2.47**	**0.49**	**0.000**	**0.600**
Supply risk management	**1.95**	**2.35**	**0.40**	**0.000**	**0.586**
e-procurement tools	**1.73**	**2.16**	**0.43**	**0.000**	**0.567**
Pooling, planning and organizing	**2.07**	**2.48**	**0.41**	**0.000**	**0.550**
Sustainable purchasing	**2.12**	**2.48**	**0.36**	**0.000**	**0.534**
Value analysis	**2.27**	**2.63**	**0.36**	**0.000**	**0.512**
AI Knowledge	1.79	2.14	0.35	0.000	0.477
Change management	2.07	2.42	0.35	0.000	0.473
Innovation implementation	1.90	2.26	0.36	0.000	0.467
Automation skills	1.90	2.27	0.37	0.000	0.463
Innovation sourcing	1.96	2.26	0.30	0.000	0.449
Commodity knowledge	1.91	2.19	0.28	0.000	0.410
Financial skills	2.21	2.52	0.31	0.000	0.388
Technical knowledge of products	1.99	2.22	0.23	0.000	0.328
(Big) Data analysis	2.17	2.41	0.24	0.000	0.320
Strategic (business) skills	2.30	2.53	0.23	0.001	0.310
Project management	2.53	2.70	0.17	0.007	0.241
Working with R&D	1.97	2.15	0.17	0.009	0.224
Legal skills (basic)	2.08	2.22	0.15	0.006	0.190

*5-point-Likert Scale (1=no competence; 2=basic; 3=advanced; 4=outstanding; 5=being able to train others)

4.3 Increased performance during the assessment

Since the two sets of results presented above are based on a self-rated survey, an additional objective measure was taken by utilising an experimental control group study design. This is to compare how well students learned from the game compared to the traditional lectures. This study involved an objective measure based on 20 multiple-choice questions exam at the end of the course. For all four measurement moments, the exam was identical. Between the two moments of examination, minor differences within the groups, and a significant difference between the experimental and control groups was observed (see table 6). To test the difference between the experimental and control groups, a t-test for equality of means was performed (Field, 2018), resulting in a mean difference of 1.193, which is highly significant (N=168).

Table 6: Outcome of the experiment study

Groups	N	Mean score*
Traditional lecture 2019	26	14.65
Traditional lecture 2020	39	15.10
Serious game 2020	43	15,65
Serious game 2021	60	16.45

T-Test Equality of Means	N	Mean score*	Std. Deviation	Std. Error Mean	Mean difference	t	Significance (2-tailed)
Serious game group	103	16.12	1.838	0.181	1.193	3.769	0.000
Traditional lectures group	65	14.92	2.231	0.277			

*20 multiple-choice exam questions with four choices each, 20 points maximum score

5. Discussion and conclusion

What makes this research interesting is that the presented serious game is the first online multiplayer game within the field of PSM. It also classifies as a simulation game and is used as a case study, including student team interaction. Previous games in this field focused on the supply chain management (SCM) context, as the widely used Beer Distribution Game (Forrester, 1961) or other SCM-related gamified education examples, e.g., SC optimisation (van den Berg et al., 2017), sustainable SCM (Hidayatno et al., 2019), and humanitarian logistics (William et al., 2018). In contrast, the presented PSM related serious game focuses on PSM related decisions and skills. Especially the PSM skills needed within the current business environment. Further, the developed game was extensively evaluated based on a students' post-game survey, which indicates that the game design is well-made (Wilson et al., 2009). Within the course design and the game's progress, Garris et al. (2002) input-process-output model was used, which helped improve the learning outcomes. Students assessed high meaningfulness, enjoyment, clear objectives, the right level of abstraction, the right level of complexity, appealing aesthetics and interface, opportunities for feedback, and competitive and collaborative elements. Within the presented study, it is impossible to conclude that specific game attributes relate to specific learning outcomes, but especially the competitive and collaborative elements were standing out as success factors to design a serious game (Bedwell et al., 2012). Besides the effective game design, it was also possible to show that students see serious games as a useful educational method. In addition, the experimental control group design concluded that there is a significant difference within the learning outcome based on the multiple-choice exam results, where students who played the game score significantly higher. Lastly, the research supports gamification principles and techniques that help develop a useful game for education (Bedwell et al., 2012, Mora et al., 2017, William et al., 2018).

6. Limitations and further research

To increase the validity of the results, multiple control variables were included as the timing of the lectures, the professionality of the lecturer, and the students' energy level. However, these variables were not presented due to the length of this conference paper. Still, the reliability of the group comparison experiment is questionable, comparing a bachelor and a master study program. Further, the research did not consider the additional time needed to play the serious game compared to the traditional lecture approach. Thus the efficiency of the learning method cannot be estimated. Nevertheless, the effectiveness and good design of the game can be confirmed. Future research should continue with the analysis of serious game effectiveness and efficiency. Also, the presented research does not address the long-term effects of serious games. Research is needed that collects data over a longer period. Last, gamification principles like recognising learner diversity (Brauner et al., 2016) and stealth learning (Aguiar and Nakano, 2017) were not subject to this research.

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