GAME ON! SERIOUS GAMES IN OPERATIONS RESEARCH AND MANAGEMENT SCIENCES APPLIED TO HEALTHCARE: A SYSTEMISED LITERATURE REVIEW

M. van Zyl-Cillié[1*]

ARTICLE INFO

Article details
Presented at the 2nd International Conference on Industrial Engineering, Systems Engineering and Engineering Management, held from 2 to 4 October 2023 in Somerset West, South Africa

Available online 17 Nov 2023

Contact details
* Corresponding author
Maria.vanzyl@nwu.ac.za

Author affiliations
1 School of Industrial Engineering, North-West University, Potchefstroom, South Africa

ORCID® identifiers
M. van Zyl-Cillié
https://orcid.org/0000-0003-3320-706X

DOI
http://dx.doi.org//10.7166/34-3-2949

ABSTRACT

The effective planning and control of healthcare systems are receiving growing research interest owing to their complexities and the importance of healthcare to society. Techniques in operations research and management science (ORMS) have successfully addressed the challenges associated with healthcare service delivery. Serious gaming and classroom games have proven to be an effective tool for teaching ORMS concepts to be applied to healthcare, since they illustrate complex ideas and theories practically in a realistic setting. This research is a systemised literature review of serious gaming in the ORMS domains. It aims to assess which ORMS games could be adapted to teach ORMS concepts applied to healthcare. The research also assesses whether these games align with experiential learning pedagogy. The research is useful to both academics and practitioners who aim to improve healthcare systems while simultaneously conveying ORMS concepts to a wide audience by means of serious gaming.

OPSOMMING

Die effektiewe beplanning en beheer van gesondheidsorgstelsels geniet toenemende navorsingsbelangstelling vanweë hul kompleksiteit en die belangrikheid van gesondheidsorg vir die samelewing. Tegnieke in operasionele navorsing en bestuurswetenskap (ORMS) spreek die uitdagings wat verband hou met gesondheidsorgdienslewering suksesvol aan. Daar is bewys dat ernstige speletjies en klaskamerspeletjies 'n effektiewe hulpmiddel is om ORMS-konsepte te onderrig wat op gesondheidsorg toegepas kan word, aangesien dit komplekse idees en teorieë prakties in 'n realistiese omgewing illustreer. Hierdie navorsing is 'n gesistematiseerde literatuuroorsig van ernstige speletjies in die ORMS-domein. Dit is daarop gemik om te bepaal watter ORMS-speletjies aangepas kan word om ORMS-konsepte aan te leer wat op gesondheidsorg toegepas kan word. Die navorsing beoordeel ook of hierdie speletjies ooreenstem met ervaringsleerpedagogie. Die navorsing is nuttig vir beide akademici en praktisyns wat daarop gemik is om gesondheidsorgstelsels te verbeter en terselfdertyd ORMS-konsepte aan 'n wye gehoor oor te dra deur middel van ernstige speletjies.

1. INTRODUCTION

1.1. Background

Healthcare organisations worldwide face problems in delivering healthcare services effectively, on time, and with limited resources [1], [2]. The increased demand for healthcare services and the resulting increased spending in the sector have resulted in the need for healthcare organisations to rethink their processes and how to plan, organise, and control resources and processes more effectively [3]. The field of operations research and management science (ORMS) is defined as an interdisciplinary field that stems from applied mathematics, engineering, and management sciences, and that aims to improve operational processes and decision-making [4]. ORMS has been successfully applied in healthcare by guiding capacity planning and control decisions, leading to improved efficiencies [2]. Some examples of this are operating room planning, nurse and bed scheduling, improving waiting times in a hospital environment, and reducing delays in emergency departments [5]–[10].

Operations research and management is taught in many industrial engineering and management science courses internationally and in South Africa [11]–[14]. The format ranges from modules that form part of the qualification's curriculum to short courses that are presented to practitioners in industry [15]. Since the concepts of ORMS have traditionally been applied in the manufacturing environment [16], examples from manufacturing are predominantly used to illustrate ORMS concepts to students. Healthcare systems and services that require the application of ORMS principles do, however, face unique difficulties. First, although manufacturing principles are undoubtedly relevant for planning and control decisions in healthcare, healthcare systems are categorised as a service system. The traditional manufacturing work-in-progress in the case of health systems is patients who are either undergoing treatment or waiting for access to treatment and healthcare services. Patients are sensitive to waiting times from both a patient experience perspective and a clinical outcome perspective [2]. Teaching ORMS concepts with the aim of applying it to a healthcare environment needs to take such complexities of healthcare systems into account.

Traditional teaching methods in which information is imparted to students who take notes are often employed to convey content [17]. The students play a passive role in such a scenario, and little to no experiential learning occurs.

Classroom games, also called serious games [18], can be used successfully as a pedagogical tool to engage students and to convey ORMS concepts to them [19]. The term 'serious gaming' describes games that are not specifically designed for entertainment but are used in training and education [20].

1.2. Purpose of the study

The purpose of this study is to determine, first, which classroom games have been developed in the operations management and science domain, and to assess to what extent pedagogical theory on experiential learning was considered in the design. Second, this study aims to determine which classroom games in ORMS could be adapted for teaching ORMS as applied to healthcare.

1.3. Literature review

In this section, we first provide a brief overview of some pedagogical theory that is applicable to this research, and then describe Bloom's taxonomy on how knowledge is processed.

In order to understand the purpose and objective of classroom games, it is necessary to take cognisance of how people learn. Many pedagogical theories exist, and the work of Karl Popper is often referenced when answering the question of how people learn [21]. According to Popper, learning takes place when one encounters a problem. We attempt to solve this problem, which leads to a specific outcome. Both a positive and a negative outcome of the solution to the problem will lead to learning. A positive outcome will teach a person what the correct solution to the problem is, while a negative outcome will generally lead someone to solve the problem in a different way. This implies that they will attempt to solve a different version of the original problem again. The first problem differs from the second problem because errors occur when the initial solution is attempted in solving the first problem.

This process is illustrated as follows

$$P_1 \rightarrow TS \rightarrow EE \rightarrow P_2 \quad (1)$$

This equation, adapted from [21], shows that P_1 is the initial problem that needs solving; then we attempt a trial solution TS to solve the problem. This initial solution is subject to error elimination (EE), which is how the next problem, P_2, is created. Through this process, change occurs in ourselves and the world around us. This change within us is called learning [21].

Another well-known theory on learning and how individuals construct meaning is Kolb's experiential learning cycle [21]. This theory posits that individuals learn and make meaning of information more effectively through experience than through passive listening [17]. According to this theory of experiential learning, individuals progress through a natural cycle of learning as follows [17]:

- Perceiving a situation (concrete experience)
- Reflecting on what was observed (assessment)
- Abstracting concepts from the experience (mapping/designing concepts)
- Experimenting actively (applying the concepts to the situation)

In their work on transdisciplinary experiential learning in biomedical engineering education, Montesinos *et al*. [17] argue that learning experiences need to be designed by taking Kolb's experiential learning cycle into account. This means that students need to be actively involved in the design of an experience such as a classroom game. First, they need to be a) guided on what to observe (concrete experience); b) prompted to reflect on the experience (assessment); c) guided toward conceptualising the experience; and d) encouraged to provide alternative solutions and designs for the problem. The final step would allow problem-solving and decision-making skills to be developed [17].

In order to use classroom games effectively as experiential learning opportunities, the well-known foundational taxonomy of Bloom needs to be taken into account. Bloom's taxonomy was created in 1956 as a tool to classify the objectives of what students need to learn [22]. The taxonomy has six categories that range from simple to complex. The taxonomy has undergone numerous revisions since 1956 [22]; we present the most recent version of the taxonomy below [23].

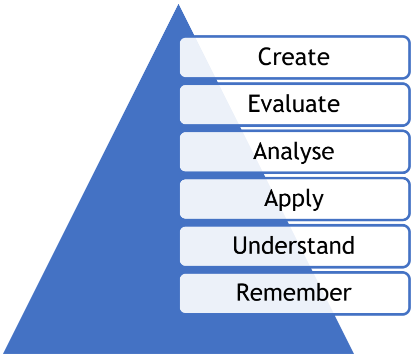

Figure 1: Bloom's taxonomy (adapted from [23])

The pyramid describes how students cognitively process knowledge [23] from simplicity to complexity. In the simplest form, information is remembered and facts can be regurgitated. The next step in the process is to understand the information and be able to explain the ideas related to the information. Once this information can be used to solve unfamiliar problems, the 'apply' stage of the hierarchy is reached. The stage after that is concerned with drawing connections between ideas ('analyse'), after which these ideas can be critically judged ('evaluate'). Finally, the 'create' stage of the pyramid is reached when new artefacts or knowledge are created [23].

Bloom's taxonomy is useful – even essential – in assessing classroom games in the field of ORMS. The purpose of the games, and how players of the games are intended to process knowledge, are evaluated below by using this taxonomy and Kolb's experiential learning cycle.

2. RESEARCH METHOD

This section explains the research method that was followed to identify classroom games and serious games in the ORMS field. First we conducted a systemised literature review. A systemised literature review differs from a systematic literature review in that no reporting standard for the synthesis of results such as PRISMA (preferred reporting items for systematic reviews and meta-analysis) is required. A systemised literature review was more suitable for this study, since this type of review allows for the synthesis of results to use a tabular format with additional narrative, and is not subject to specific reporting standards [24].

Table 1 shows the phrases and synonyms for the literature search.

Table 1: Search phrases for systemised literature review

Search part	Search phrases
Gaming	“classroom game”, “classroom games”, “classroom gaming”, “simulation game”, “simulation games”, “simulation gaming”, “serious game”, “serious games”, “serious gaming”
Operations research and management science	“operations research”, “operations management”, “operational research”

The search was done on titles, abstracts, and keywords in the Scopus and Web of Science databases. The following Boolean search term, based on the synonyms of Table 1, was used:

> “classroom game*” OR “classroom gaming” OR “simulation game*” OR “simulation gaming” OR “serious game*” OR “serious gaming” AND “operations research” OR “operations management” OR “operational research”

This resulted in a total of 127 records. All non-English records were excluded, and 124 records remained. Once duplicates had been removed, the exclusion criteria i and ii were applied to the titles of 91 records. The exclusion criteria were as follows:

i. Exclude all records for which the application is not in the field of ORMS
ii. Exclude all records that are not related to classroom games, serious gaming, OR simulation games
iii. Exclude all records that do not specifically describe a game

Fifty records remained after the first two exclusion criteria had been applied. The abstracts of all 50 records were read, and the third exclusion criterion (iii) was applied. The result was that 22 records were removed and 26 records remained. The full texts of all 26 records were read and analysed. The article tree of the search process is shown in Figure 2.

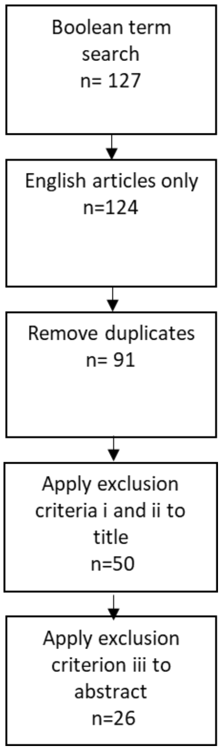

Figure 2: Article tree

3. ANALYSIS AND RESULTS

The 26 records that were analysed in this systemised review were predominantly journal articles, as shown in Figure 3.

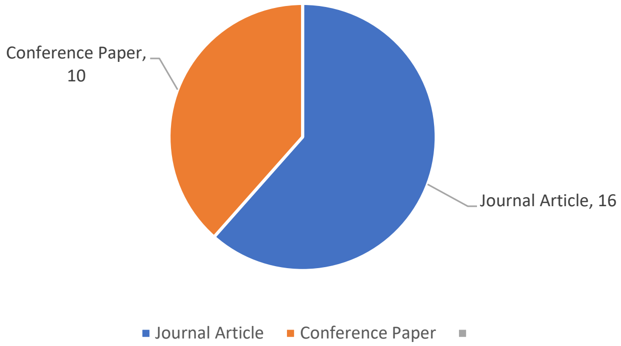

Figure 3: Number of records per publication type

When assessing the publication dates, all records prior to 2010 were grouped together. Figure 4 shows the number of records published per publication type per year.

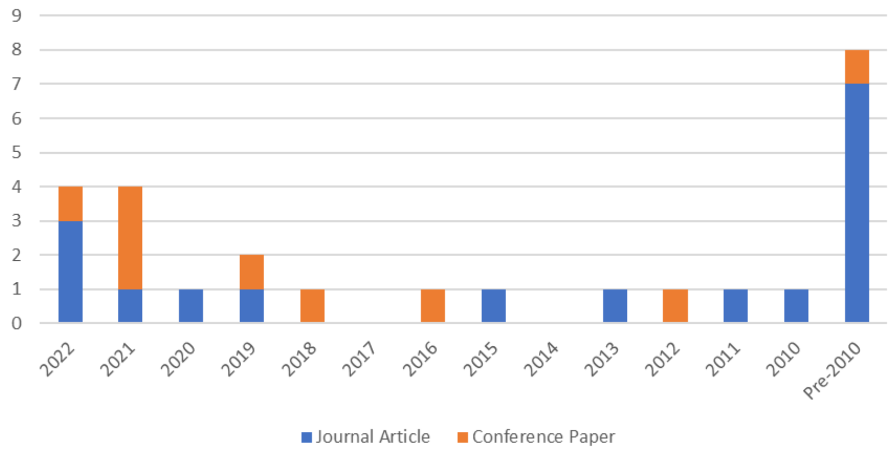

Figure 4: Number of records per publication type per year

Prior to 2019, relatively little work was done on developing games as experiential learning tools in the field of ORMS. It also appears that the research prior to 2019 was predominantly published in journal articles. From 2019 onwards, and especially around 2021, a clear interest in developing games in ORMS, and especially in presenting them at conferences, is evident. The Covid19 pandemic most likely had an impact on the increased interest in the field: teaching and learning moved to online platforms during and after the pandemic, and such platforms strongly lend themselves to the use of serious games as experiential learning tools.

Since the aim of the research was also to assess how ORMS classroom games that are described in the literature could be used as experiential learning tools in ORMS as applied to healthcare, we assessed the games in the 27 records as follows.

First, we assessed the games by identifying the field of ORMS that the games explore. We then used the guiding questions proposed by Montesinos *et al.* [1] and described in section 2 to determine whether the game was designed to take Kolbe's experiential learning cycle into account. Records were assigned some or all of the symbols shown in Table 2, depending on whether or not the games' design took Kolbe's experiential learning cycle into account.

Table 2: Symbols to denote Kolb's cycle

Symbol	Stage in Kolb's cycle of experiential learning	Questions to determine stage in Kolbe's cycle of experiential learning
C	Concrete experience	Are students guided in what to observe?
A	Assessment	Are students prompted to reflect on the experience?
M	Mapping/designing concepts	Are students guided in conceptualising the experience?
E	Experimenting actively	Are students encouraged to provide alternative solutions to the problems?

The degree of complexity with which the game prompts students to process knowledge on the topics of the game was then determined by using Bloom's taxonomy. Once again, a symbol was given to each article by answering the question: "At which level of Bloom's taxonomy does the game prompt students to process knowledge?"

The symbols that were used were 'R' for remember, 'U' for understand, 'Ap' for apply, 'Al' for analyse, 'E' for evaluate, and 'C' for create.

Finally, each game in the processed articles was assessed to determine whether it could be adapted to teach the complexities of ORMS as applied to healthcare. Aspects such as whether the game had been created in a specific gaming environment and whether the topics of the game could be adapted to a healthcare setting were considered. The Likert scale shown in Table 3 was used to assign a rating to each game.

Table 3: Likert scale of adaptability of the game for ORMS as applied to healthcare

Very unlikely	Unlikely	Uncertain	Most likely	Definitely
1	2	3	4	5

The assessment of each record according to the discussed criteria is summarised in Table 4.

Table 4: Assessment of literature records

Record title	Reference	Field of ORMS	Stage in Kolbe's cycle	Level in Bloom's taxonomy	Adaptability for ORMS as applied to healthcare
A heuristic-based simulation for an education process to learn about optimization applications in logistics and transportation	[25]	Operations Research (Heuristics/ Analytics)	C,A,M,E	E	4
A cooperative and competitive serious game for operations and supply chain management – Didactical concept and final evaluation	[26]	Supply Chain Management (Sales and Operations Planning)	C,A	Ap	2

Record title	Reference	Field of ORMS	Stage in Kolbe's cycle	Level in Bloom's taxonomy	Adaptability for ORMS as applied to healthcare
An exploratory research on adaptability and flexibility of a serious game in operations and supply chain management	[27]	Supply Chain Management (Sales and Operations Planning	C,A	Ap	2
Physical and virtual game based experiential learning for supply chain and operations management teaching practice and effectiveness	[28]	Supply Chain Management (Sales and Operations Planning, Demand Forecasting	C,A,M	Al	3
Unity3D-based simulation for operations management teaching	[29]	Operations Management (Material Supply, Demand Management, Order Fulfilment)	C,A,M	Al	2
Lead-time manager: Design, implementation and use cases of an operations management simulation game	[30]	Operations management	Unknown	Unknown	N/A
Experiencing the role of cooperation and competition in operations and supply chain management with a multiplayer serious game	[31]	Supply chain management (sales forecasting, quality management, customer segmentation	C,A,M,E	E	2
Teaching lean principles in nonmanufacturing settings using a computer equipment order quotation administrative process	[32]	Lean, continuous improvement	C,A,M,E	E	4
An experiential approach to teaching structural decision areas in operations strategy – The TANGOS exercise	[33]	Operations management (strategy, production models, capacity planning, facility layout)	C,A,M,E	E	4

Record title	Reference	Field of ORMS	Stage in Kolbe’s cycle	Level in Bloom’s taxonomy	Adaptability for ORMS as applied to healthcare
Mathematical modeling education using an online serious game	[34]	Prescriptive analytics (mathematical modelling, heuristic algorithm)	C,A,M,E	C	2
Lost: A serious game to develop a comprehensive vision of logistics	[35]	Supply chain management (logistics)	C,A,M,E	E	2
Cash beer game	[36]	Supply chain management (inventory management, bullwhip effect), financial management (cash flow)	C,A,M	Al	1
Use of a serious game for teaching operations programming: Students' perceptions	[37]	Operations management (job scheduling)	C,A,M,E	E	4
Transportation services game: A practical tool to teach outsourcing concepts on logistics	[38]	Supply chain management (logistics, outsourcing)	C,A,M,E	Al	2
Utilizing a simulation exercise to illustrate critical inventory management concepts	[39]	Supply chain management (inventory management)	C,A,M	Al	2
A simulation based game approach for teaching operations management topics	[40]	Operations management (capacity management, maintenance planning)	C,A,M,E	Al	3
The impact of a simulation game on operations management education	[41]	Operations management (materials requirement planning, capacity planning)	C,A,M	Ap	2
Operations strategy with paper boats	[42]	Operations management (strategy, quality management, production planning)	C,A,M,E	Al	2

Record title	Reference	Field of ORMS	Stage in Kolbe's cycle	Level in Bloom's taxonomy	Adaptability for ORMS as applied to healthcare
Logistic Game™: Learning by doing and knowledge-sharing	[43]	Supply chain management (logistics), financial management	C,A,M,E	E	2
Simulation as a tool for gaming and training in operations management – A case study	[44]	Operations management (Takt time, resource allocation)	C,A,M,E	Al	2
Learning and practising supply chain management strategies from a business simulation game: A comprehensive supply chain simulation	[45]	Supply chain management (order fulfilment cycle, inventory management, logistics)	C,A,M,E	E	2
Learn more, better and faster: computer-based simulation gaming of production and operations	[46]	Operations management	Unknown	Ap	2
Learning the theory of constraints with a simulation game	[47]	Operations management (theory of constraints)	Unknown	Unknown	N/A
Simulation, gaming and training in a competitive, multimodal, multicompany, intercity passenger-transportation environment	[48]	Operations management (demand management, resource allocation)	C,A,M,E	E	4
A flexible web-based simulation game for production and logistics management courses	[49]	Supply chain management (inventory management, outsourcing), logistics	C,A,M	Al	2
Teaching supply chain management using a modified beer game: An action learning approach	[50]	SCM (bullwhip effect, inventory management, demand forecasting)	C,A,M	E	4

4. CONCLUSION

The use of serious gaming and classroom games to teach ORMS concepts seems to have gained interest in the past few years. Although many of these serious games are designed to be played in an online environment, many simulation games such as the beer game or its variations can be played in a physical classroom environment[50].

Our research indicated that the majority of serious games in the field of ORMS focus on supply chain management or operations management principles, and that very few games explore operational research theory. Furthermore, our search did not find any serious games on ORMS as applied to healthcare. Given the nature of serious games, which require players to make a decision at some point, the majority of games adhere to the four steps in Kolb's experiential learning cycle. The last step (experiment actively) is generally part of the game design. Although the third step of Kolb's cycle of experiential learning (mapping/designing concepts) was present in most of the games we investigated, it was not always clear to what degree students were allowed to conceptualise the experience.

We found further that only one of the games on mathematical modelling [34] allowed students to create an artefact (in this case, a mathematical model). Since students made decisions and could see the outcome of their decisions, many of the games were positioned on the 'evaluate' level of Bloom's taxonomy.

We conclude that serious games that are coded for a specific environment are not easy to adapt to healthcare applications. Furthermore, most games focus on the manufacturing environment, and the concepts that these games convey are not always applicable to the complexities of healthcare.

Six of the 26 games that were evaluated seemed to be adaptable to a healthcare application. This was mainly because the games were not developed to be played in only one specific environment. We contend that the game presented by Terpend *et al.* [32] is best suited to adapting for a healthcare setting, since it teaches lean principles for a non-manufacturing environment. In addition, Ammouriova *et al.* [25] use a heuristic-based simulation to teach students about optimisation in the transportation sector. Although the game is not specifically tailored to the healthcare environment, it may be suited to imparting knowledge on OR principles, and could be adapted to include healthcare analogies. The implications for serious gaming in healthcare of both of these games, however, are that significant additional development would have to take place to make these games readily applicable to a specific healthcare context.

Finally, we conclude that there is a significant research opportunity to develop serious games in ORMS, particularly for application in the healthcare environment. There is also a need for guidelines on how to design serious games as effective experiential learning tools that adhere to best pedagogical practice.

"Tell me and I forget, teach me and I may remember, involve me and I learn."
Xun Kuang – Chinese Confucian philosopher

REFERENCES

[1] Montesinos, D. E. Salinas-Navarro, and A. Santos-Diaz, "Transdisciplinary experiential learning in biomedical engineering education for healthcare systems improvement," *BMC Medical Education*, vol. 23, no. 1, 207, 2023.

[2] M. van Zyl-Cillié, D. Demirtas, and E. Hans, "Wait! What does that mean? Eliminating ambiguity of delays in healthcare from an OR/MS perspective," *Health Systems*, vol. 12, no. 1, pp. 3-21, 2022. doi: https://doi.org/ 10.1080/20476965.2021.2018362

[3] E. W. Hans, M. van Houdenhoven, and P. J. H. Hulshof, "A framework for healthcare planning and control," in *Handbook of healthcare system scheduling*. International Series in Operations Research & Management Science, vol. 168. Boston MA: Springer, 2012, pp. 303–320. doi: https://doi.org/10.1007/978-1-4614-1734-7_12

[4] The Institute for Operations Research and the Management Sciences. "INFORMS." https://www.informs.org/ [accessed Jun. 06, 2023].

[5] R. M'Hallah and A. H. Al-Roomi, "The planning and scheduling of operating rooms: A simulation approach," *Computers and Industrial Engineering*, vol. 78, pp. 235–248, 2014. doi: https://doi.org/10.1016/j.cie.2014.07.022

[6] F. de Véricourt and O. B. Jennings, "Nurse staffing in medical units: A queueing perspective," *Operations Research*, vol. 59, no. 6, pp. 1320–1331, 2011. doi: https://doi.org/10.1287/ opre.1110.0968

[7] R. Bekker, G. Koole, and D. Roubos, "Flexible bed allocations for hospital wards," *Health Care Management Science*, vol. 20, no. 4, pp. 453–466, 2017. doi: https://doi.org/ 10.1007/s10729-016-9364-4

[8] A. J. Thomas Schneider *et al.*, "Allocating emergency beds improves the emergency admission flow," *Interfaces (Providence)*, vol. 48, no. 4, pp. 384–394, 2018. doi: https://doi.org/ 10.1287/inte.2018.0951

[9] J. T. van Essen, E. W. Hans, J. L. Hurink, and A. Oversberg, “Minimizing the waiting time for emergency surgery,” *Operations Research for Health Care*, vol. 1, no. 2–3, pp. 34–44, 2012. doi: https://doi.org/10.1016/j.orhc.2012.05.002

[10] J. C. A. M. van Beers, D. H. van Dun, and C. P. M. Wilderom, “Effective hospital-wide lean implementation: Top-down, bottom-up or through co-creative role modeling?” *International Journal of Lean Six Sigma*, vol. 13, no. 1, pp. 46–66, 2022. doi: https://doi.org/10.1108/IJLSS-02-2021-0024

[11] North-West University. “NWU Industrial Engineering”. https://engineering.nwu.ac.za/industrial-engineering [accessed Jun. 06, 2023].

[12] Stellenbosch University. “]Industrial Engineering-Stellenbosch University”. https://ie.sun.ac.za/ [accessed Jun. 06, 2023].

[13] University of Pretoria.“ Industrial and Systems Engineering.” https://www.up.ac.za/yearbooks /2016/pdf/programme/12130011 [accessed Jun. 06, 2023].

[14] University of Twente. “University Twente Industrial Engineering.” https://www.utwente.nl/en/ education/bachelor/programmes/industrial-engineering-and-management/ [accessed Jun. 06, 2023].

[15] North-West University. “NWU MBA.” https://www.nwu.ac.za/nwu-business-school/masters-business-administration [accessed Jun. 06, 2023].

[16] P. J. H. Hulshof, N. Kortbeek, R. J. Boucherie, E. W. Hans, and P. J. M. Bakker, “Taxonomic classification of planning decisions in health care: A structured review of the state of the art in OR/MS,” *Health Systems*, vol. 1, no. 2, pp. 129–175, 2012. doi: https://doi.org/10.1057/hs.2012.18

[17] L. Montesinos, D. E. Salinas-Navarro, and A. Santos-Diaz, “Transdisciplinary experiential learning in biomedical engineering education for healthcare systems improvement,” *BMC Medical Education*, vol. 23, no. 1, 207, 2023. doi: https://doi.org/10.1186/s12909-023-04171-x

[18] D.-J. van der Zee, B. Holkenborg, and S. Robinson, “Conceptual modeling for simulation-based serious gaming,” *Decision Support Systems*, vol. 54, no. 1, pp. 33–45, 2012.

[19] P. Griffin, “The use of classroom games in management science and operations research,” *INFORMS Transactions on Education*, vol. 8, no. 1, pp. 1–2, 2007. doi: https://doi.org/10.1287/ited.8.1.1

[20] W. Westera, “Examining the productiveness of failure in serious gaming,” *International Journal of Technology Enhanced Learning*, vol. 14, no. 1, pp. 66–87, 2022.

[21] J. Swann, “What happens when learning takes place?” *Interchange*, vol. 30, pp. 257–282, 1999.

[22] D. R. Krathwohl, “A revision of Bloom’s taxonomy: An overview,” *Theory into Practice*, vol. 41, no. 4, pp. 212–218, 2002. doi: https://doi.org/ 10.1207/s15430421tip4104_2

[23] P. Armstrong, “Bloom’s taxonomy. Vanderbilt University Center for Teaching,” 2010. https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/ [accessed Jun. 07, 2023].

[24] M. J. Grant and A. Booth, “A typology of reviews: An analysis of 14 review types and associated methodologies,” *Health Information and Libraries Journal*, vol. 26, no. 2, pp. 91–108, 2009. doi: https://doi.org/10.1111/j.1471-1842.2009.00848.x

[25] M. Ammouriova, M. Bertolini, J. Castaneda, A. A. Juan, and M. Neroni, “A heuristic-based simulation for an education process to learn about optimization applications in logistics and transportation,” *Mathematics*, vol. 10, no. 5, 830, 2022. doi: https://doi.org/ 10.3390/math10050830

[26] G. Romagnoli, M. Galli, D. Mezzogori, and D. Reverberi, “A cooperative and competitive serious game for operations and supply chain management — Didactical concept and final evaluation,” *International Journal of Online and Biomedical Engineering*, vol. 18, no. 15, pp. 17–30, 2022. doi: https://doi.org/10.3991/ijoe.v18i15.35089

[27] G. Romagnoli, M. Galli, D. Mezzogori, and F. Zammori, “An exploratory research on adaptability and flexibility of a serious game in operations and supply chain management,” *International Journal of Online and Biomedical Engineering*, vol. 18, no. 14, pp. 77–98, 2022. doi: https://doi.org/10.3991/ ijoe.v18i14.35083

[28] M. der May, “Physical and virtual game based experiential learning for supply chain and operations management teaching practice and effectiveness,” *IEEE Global Engineering Education Conference, EDUCON*, IEEE Computer Society, 2022, pp. 1113–1120. doi: https://doi.org/10.1109/ EDUCON52537.2022.9766394

[29] J. Pernas-Álvarez and D. Crespo-Pereira, “Unity3D-based simulation for operations management teaching,” *20th International Conference on Modeling and Applied Simulation*, 2021, pp. 136–140.

[30] J. Weiss, “Lead-time manager: Design, implementation and use cases of an operations management simulation game,” *Operations Management Education Review*, 2021.

[31] M. Galli, D. Mezzogori, D. Reverberi, G. Romagnoli, and F. Zammori, “Experiencing the role of cooperation and competition in operations and supply chain management with a multiplayer serious game,” *IFIP Advances in Information and Communication Technology*, 2021, pp. 491–499. doi: https://doi.org/10.1007/978-3-030-85910-7_52

[32] R. Terpend and P. Shannon, "Teaching lean principles in nonmanufacturing settings using a computer equipment order quotation administrative process," *Decision Sciences Journal of Innovative Education*, vol. 19, no. 1, pp. 63–89, 2021. doi: https://doi.org/10.1111/dsji.12227

[33] S. Wilson, "An experiential approach to teaching structural decision areas in operations strategy — The TANGOS exercise," *INFORMS Transactions on Education*, vol. 20, no. 2, pp. 113–123, 2020. doi: https://doi.org/10.1287/ITED.2019.0219

[34] I. K. Singgih and N. F. Ferdinand, "Mathematical modeling education using an online serious game," *Proceedings of 2019 5th International Conference on New Media Studies, CONMEDIA 2019*, 2019, pp. 184-188.

[35] E. Pacheco-Velazquez, J. Palma-Mendoza, I. Arana-Solares, and T. Cotera Rivera, "Lost: A serious game to develop a comprehensive vision of logistics," *Proceedings of the European Conference on Games-based Learning*, 2019, pp. 550-559.

[36] K. Shang, "Cash beer game," *Foundations and Trends in Technology, Information and Operations Management*, Vol. 12, No. 2-3, pp. 173-188, 2019.

[37] G. L. Carmona Gonzalez, L. E. Pelaez Valencia, and H. Trefftz, "Use of a serious game for teaching operations programming: Students' perceptions," *Proceedings - 2018 International Conference on Computational Science and Computational Intelligence, CSCI 2018*, 2018, pp. 667–670. doi: https://doi.org/10.1109/CSCI46756.2018.00134

[38] A. G. de Leao, "Transportation services game: A practical tool to teach outsourcing concepts on logistics," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol 9599. 2016. doi: https://doi.org/10.1007/978-3-319-40216-1_41

[39] E. Umble and M. Umble, "Utilizing a simulation exercise to illustrate critical inventory management concepts," *Decision Sciences Journal of Innovative Education*, vol. 11, no. 1, pp. 13–21, 2013. doi: https://doi.org/10.1111/j.1540-4609.2012.00364.x

[40] F. Costantino, G. di Gravio, A. Shaban, and M. Tronci, "A simulation based game approach for teaching operations management topics," in *Proceedings — Winter Simulation Conference*, 2012, pp 1-12

[41] F. Pasin and H. Giroux, "The impact of a simulation game on operations management education," *Computers & Education*, vol. 57, no. 1, pp. 1240–1254, 2011. doi: 10.1016/j.compedu.2010.12.006

[42] N. Sumukadas, "Operations strategy with paper boats," *Simulation & Gaming*, vol. 41, no. 3, pp. 432–444, 2010. doi: https://doi.org/ 10.1177/1046878109334946

[43] D. Battini, M. Faccio, A. Persona, and F. Sgarbossa, "Logistic GameTM: Learning by doing and knowledge-sharing," *Production Planning and Control*, vol. 20, no. 8, pp. 724–736, 2009. doi: https://doi.org/10.1080/09537280903119056

[44] D. J. van der Zee and J. Slomp, "Simulation as a tool for gaming and training in operations management — A case study," *Journal of Simulation*, vol. 3, no. 1, pp. 17–28, 2009. doi: https://doi.org/10.1057/jos.2008.8

[45] L. Zhou, Y. Xie, N. Wild, and C. Hunt, "Learning and practising supply chain management strategies from a business simulation game: A comprehensive supply chain simulation," in *Proceedings — Winter Simulation Conference*, 2008, pp. 2534-2542. doi: https://doi.org/ 10.1109/WSC.2008.4736364

[46] T. Lainema and O.-P. Hilmola, "Learn more, better and faster: computer-based simulation gaming of production and operations," *International Journal of Business Performance Management*, vol. 7, no. 1, pp. 34-59, 2005.

[47] S. S. Chakravorty and P. R. Verhoeven, "Learning the theory of constraints with a simulation game," *Simulation & Gaming*, vol. 27, no. 2, 1996.

[48] C. Lardinois, "Simulation, gaming and training in a competitive, multimodal, multicompany, intercity passenger-transportation environment," *The Journal of the Operational Research Society*, vol. 40, no. 10, pp. 849-861, 1989.

[49] Y.-C. Chang, W.-C. Chen, Y.-N. Yang, and H. C. Chao, "A flexible web-based simulation game for production and logistics management courses," *Simulation Modelling Practice and Theory*, vol. 17, pp. 1241-1253, 2009. [accessed Jun. 07, 2023].

[50] A. K. W. Lau, "Teaching supply chain management using a modified beer game: An action learning approach," *International Journal of Logistics Research and Applications*, vol. 18, no. 1, pp. 62–81, 2015. doi: https://doi.org/ 10.1080/13675567.2014.945398