A GAME-BASED LEARNING COURSE FOR EDUCATION ON REMANUFACTURING SUPPLY CHAINS

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Abstract: Increased material demand, scarcity issues and environmental awareness foster the need of remanufacturing. Even though the theoretical foundation of closed-loop supply chains is well developed, its implementation in education and practice still lacks momentum. Special characteristics of remanufacturing, such as the complexity caused by the united role of customer and supplier and remaining supply issues, require according education on remanufacturing topics for future supply chain managers. Game-based learning (GBL) has a long tradition within management education, and is proven effective specifically for complex systems. However, there are no articles addressing the use of GBL for remanufacturing. This article is addressing this gap. Based on the challenges and educational needs it presents a curriculum on remanufacturing using a blended learning concept and adaption of an existing game.

Keywords: Game-Based Learning; Remanufacturing; Supply Chain Management.

INTRODUCTION

It is assumed that remanufacturing (reman) has an economic and ecologic advantage (Östlin *et al.*, 2009, p. 999). In addition, due to the increasing demand for resources (UNEP, 2013), the volatility on the commodity markets, and scarcity issues, there is a need for alternative resource supply. Furthermore, consumers and policy makers are increasingly aware of the environmental impact of resource usage (Swarr, 2009; Agrawal, 2012). This development generates a demand for reman, as it requires less input of primary resources and contributes to lower emissions.

Although preferable from a sustainability perspective, reman cannot always capitalize on the implied advantages, partly due to supply and procurement issues. The literature focuses on approaches for system/network design (e.g. Jayaraman *et al.*, 2003), capacity planning (e.g. Georgiadis and Athanasiou, 2013) or ownership issues (Östlin *et al.*, 2009). Especially the normative field of research on reman is advanced (Guide and van Wassenhove, 2008). However, the transfer into practice

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still lacks some momentum and no substantial literature was identified regarding reman as a focus for educational programs or courses.

A recent study from APICS (2014) revealed that new competencies are required for supply chain management (SCM) for reman. The study concluded that methods and tools used for traditional supply chains (SCs) can hardly be transferred to reverse chains, which is mainly due to the specific situation of customers and suppliers in this field. Procurement, customer service and resource competition are fields of increasing importance due to the growing demand of reman. Furthermore, for reman the identification of sources of used parts is critical to ensure supply (Guide and van Wassenhove, 2008). Hence, competencies related to communication and interaction with potential suppliers, i.e. relationships, play a crucial role.

The two main questions in this article are therefore which additional competencies do future managers need and how should these be conveyed. Besides the operational knowledge, future SC managers need to know how to address the special requirements of reman SCs. The competencies listed above show that managers also need methodological competencies. Within business and engineering schools experiential learning approaches (Kolb, 1984; Riedel and Baalsrud Hauge, 2011) have a long tradition, especially to learn how to applying methods in complex systems and to acquire social skills. Thus, the next section deals with the state of the art of game-based learning in manufacturing and SCs.
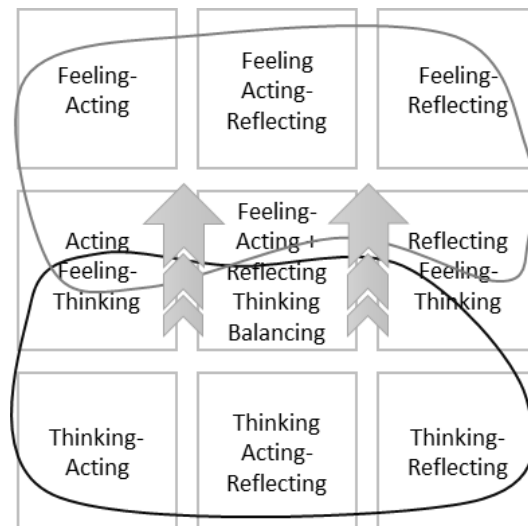
Game-based Learning

Game-based learning (GBL) provides a learning environment where experiences and feedback drive the students learning process (Baalsrud Hauge, 2014); by increasing challenges and complexity, games may force the player to apply knowledge in new contexts (Gee, 2003). Games are used in different subjects of higher education (Raybourn, 2007) and games in education are considered entertaining but with non-entertaining learning objectives (Baalsrud Hauge *et al.*, 2014b). Games and simulations further allow for experiencing as well as experimenting in a safe environment (Baalsrud Hauge and Bratziotis, 2013); feedback and reflection on the game experience both by the players and by the facilitator ensure the consolidation of competencies. The transfer of competencies in traditional settings is a challenge in SCM education, therefore alternative approaches are explored (Baalsrud Hauge, 2014). Gravier and Farris (2008) give a thorough overview of the development of and changes in the education on SCM.

GBL is based on the experiential learning theory of Kolb (1984). This approach is further supported by neurological research about brain functioning, for example highlighting how Kolb's learning cycle engages different areas of the

cerebral cortex (Zull, 2004). Kolb and Kolb (2005) also developed a matrix covering nine learning spaces representing learning styles (see next section). While the dominant learning space depends on the study domain, the ability to move between different learning spaces depends on the learner's stage of development. In order to achieve the learners' movement between learning spaces, the institutional environment needs to change. The curriculum development, as in the next section, is part of this change.

Curriculum development

Based upon the educational requirements derived in sections I and II and experience of different authors (Baalsrud Hauge *et al.*, 2014a), a blended learning course (Luccini *et al.*, 2012) for reman SCs is proposed. An according curriculum in SCM should put special emphasis on outcomes related to the learning spaces that are feeling-oriented since management students typically are already well trained in the thinking-oriented spaces (Kolb and Kolb, 2005); in order to learn from other spaces it is necessary to improve the practical implementation of theoretically developed strategies, because then other spaces are affected. A simulation environment wherein students have to interact with one another targets their social skills, i.e. feeling-oriented spaces, as indicated in Figure 1.

Figure 1: Movement between dominant learning spaces: from thinking- to feeling-oriented learning spaces (matrix based on Kolb and Kolb, 2005, p. 198)

Learning goals

A GBL course on reman SCM is targeting the challenges related to the complexity of such SCs. However, this complexity has to be reduced to a level that allows the participants to properly experience and experiment. Therefore, the objectives for the course are derived from the most important issues in reman supply first. Afterwards, the environment is described which allows to aim for the training of different learning spaces.

Known issues in reman are (a) challenges related to different sourcing strategies, (b) the balancing of supply and demand for reman, (c) scattered sources, and (d) the pressure market issues put on reman supply. Some topics in SCM theoretically address these issues. However, the objective is to allow students to experience different sourcing strategies in a reman environment where the number of suppliers might not be manageable the same way as in a classic forward SC; e.g. customers become suppliers, sources are scattered and have to be consolidated. Students should be able to analyse and evaluate outcomes of such application and based upon their analysis they need to be able reorganize systems and create new knowledge (Krathwohl, 2002). Students should learn that different relationships and different market actors in SCs influence the successful implementation of the theoretical models for the design of reman SCs. By considering these aspects, the learning environment supports the movement between learning spaces. Actors have to reflect on their counterpart's activities and their own relationship towards them, though not from a technical but from a relations perspective.

Kolb's cycle and the curriculum

The course considers Kolb's learning cycle with the steps (1) concrete experience, (2) reflective observation, (3) abstract conceptualization, and (4) active experimentation. A course consists of approximately 8-10 sessions, depending on the knowledge level, and is designed for a facilitated serious game. The facilitator will summarize the theoretical background before the gaming sessions; also to adjust different knowledge levels of the students. In addition, the experience of the facilitator enriches the reflection (Baalsrud Hauge and Bratziotis, 2013), in this case especially on market and relationship issues. The whole course starts with a briefing session to reflect the previous knowledge of all students against the prerequisites of the game.

The course setting is grounded on methods and (game) mechanics closely connected to some curriculum elements. Table 1 maps these methods and mechanics to the four phases of Kolb's learning cycle. The first column indicates those phases.

Table 1: Methods and Game Mechanics supporting Kolb's learning cycle

Steps	Kolb's cycle	Methods and Mechanics
0	[Briefing]	Classic knowledge transmission
1	Concrete experience (game play)	Digital simulation game; different roles and actors; automated and facilitator driven events; Special emphasis on the supply characteristics for remanufacturing (either deposit systems, networks; or dismantlers, brokers and agents)
2	Reflective observation	Students observe their progress during the game play; KPIs from the game environment are used for initial feedback during the play After the play: Debriefing and reflection; the students analyse their decisions and behaviour, Feedback from the facilitator and a comparison and group discussion of game results from different players support this reflection.
3	Abstract conceptualization	An initial conceptualization starts already during the game play. Afterwards, the students analyse applied theoretical knowledge and the according outcome (alinement of experience with subject theory). An initial model explaining the experience might also be described. Then, individual students or in small groups use the results to explain their individual role in the game. This is already part of the preparation for the next phase.
4	Active experimentation	Development of a new experiment, i.e. testing the theory; small groups test different theories while in the 2nd experiential session (game play)

This table was elaborated according to Baalsrud Hauge (2014, p. 11).

Achieving and assessing learning goals

In order to be able to emphasize the challenges markets and relationships put on a reman SC, a game must fulfil the following requirements: (a) it needs to cover the different roles, such as customers/suppliers, agents, brokers, and producers; (b) allow for a double function of roles as customer and supplier; (c) allow for interaction and independent decision making regarding supply, i.e. to make negotiations; and (d) provide feedback to the players.

As a potential simulation environment, SECONDS – a development from BIBA (http://gaminglab.biba.uni-bremen.de) – is used to describe how to model a reman SC for the learning purposes. Furthermore, the author gained some experience with this simulation earlier and is currently involved in a scenario development based on the game. SECONDS provides the necessary flexibility in terms of configuration to adjust to different scenarios which are described via "processes" and "resources" (Baalsrud Hauge and Rust, 2012). Table 2 relates the learning goals with the requirements for a "remanufacturing game", as part of the GBL curriculum, with the characteristics of SECONDS. The fit of the requirements with SECONDS supports the selection of this game for the proposed GBL curriculum.

Table 2: Matching requirements with simulation game SECONDS

Learning goals	Requirements "reman" game	SECONDS characteristics
	Facilitated	Facilitated
Experiencing sourcing strategy impacts	Strategy selection	Decision making
Focus on remanufacturing supply chains	Remanufacturing	Producing a product (can be defined); different scenarios can be configured
Interaction, relationship management; scattered sources; customer = supplier; balancing supply and demand	Different roles, collaboration and negotiation between roles	Collaborative (no independent play), multi-player; Negotiate (suppliers, customers)
Experiencing sourcing strategy impacts	According to the selected sourcing strategy, the software behaves differently	Algorithms
Price/margins in reman; relationship management; balancing supply and demand	Reflect supply issues in reman SC	Issues (price, availability, quality, logistics costs, relationships)
	Feedback	Accounting system
		Configurable (adjust to player knowledge level)

See for SECONDS characteristics: Baalsrud Hauge and Rust (2012).

Although SECONDS can be adjusted to the needs for the developed curriculum for reman SCM, some issues remain. Furthermore, it still is necessary to ensure that the facilitator can assess learning objectives properly. One important aspect of the reman SC is the united role of costumer and supplier. The game so far only recognizes these roles as separate ones. Therefore, the game would have to be adopted accordingly.

The existing feedback system serves for the assessment of the learning objectives, though the system would need additional KPIs. For example, the amount of identified and acquired suppliers (scattered sources) as well as their reverse activities (supplier relations); interactions with customers/suppliers in relation to constant reverse flows (interaction and relationship); and the time between first available returns and provision of remanufactured parts (balance of supply and demand). Furthermore, special issues such as material value and market prices of parts can be used and correlated with according KPIs, for example through price deviation in relation to constant return flows. Although KPIs can support the assessment of some of the learning objectives, there are several limitations regarding the extension of the learning spaces and the movement in-between the spaces. Consequently, the role and capability of the facilitators of utmost importance for the learning outcome (Baalsrud Hauge *et al.*, 2014b).

Discussion and Conclusion

The education about reman SCs can help to address supply issues in practice. However, in order to achieve better reman SC performance, changes are required at different levels; such changes reach from design and engineering (design for reuse), via management (business models), until cultural and societal domains (consumption patterns). Still, as a cross-sectional domain, SCM can have an important influence on the consolidation of these developments in practice.

Usually, SCM related study programs treat education on reman SCs and reverse logistics within their courses. However, dedicated tools for the practical application and experience of the impacts of reman for supply management could not be identified. Moreover, literature revealed a need for specialized training in particular for acquisition and procurement in reman. In addition, the whole field of SCM education is looking for alternative approaches to teach SCM and to use different pedagogical approaches, such as GBL. The developed curriculum shall broaden the perspective on serious games for SCM by putting special emphasis on reman as the core process within the SC. Visualizing the differences supply for reman is facing against classical manufacturer SCs is one particular advantage of a simulation game. In this particular case, reman education could capitalize on the application of GBL courses.

The curriculum depends on an implementation of the reman scenario in the simulation game SECONDS. However, the scenario itself would have to be applied, tested and evaluated within a SCM study programs next. In addition, a revision of the chosen simulation against other options is necessary in order to ensure the best possible learning outcome; i.e. assessing whether the simulation fits to the learning objectives. Although previous applications of the game, existing evaluation and according experience of such assume a match with the requirements, further research effort is necessary to check the assumption. This applies in particular to the movement between learning spaces, which remains a challenge. Long-term assessment over additional GBL courses should support the evaluation of this particular objective.

Besides the educational advantages, a reman scenario within SECONDS could also serve as a test environment for different market scenarios, to verify assumptions about supplier relations; i.e. simulating the effect of changing market prices and analysing the players' reactions. Together with market research, this can support theory assessment and information sharing between theory and practice.

Acknowledgements

References

[1]   Agrawal, A. (2012), "Turn your reverse supply chain into a profit center", available at: http://www.supplychainquarterly.com/topics/Strategy/201201reverse/ (accessed 23 July 2014).

[2]   APICS (2014), Examining Remanufacturing In Supply Chain and Operations Management: Executive Summary, APICS Insights and Innovations.

[3]   Baalsrud Hauge, J. (2014), "The Use of Gamebased Learning Methods for Teaching Supply Chain Management Subjects", Journal of Advanced Distributed Learning Technology, Vol. 2 No. 5, pp. 5–15.

[4]   Baalsrud Hauge, J., Bellotti, F., Nadolski, R., Berta, R. and Carvalho, M.B. (2014a), "Deploying Serious Games for Management in Higher Education. Lessons learned and good practices", EAI Endorsed Transactions on Game-Based Learning, Vol. 1 No. 3, pp. e4.

[5]   Baalsrud Hauge, J., Boyle, E., Mayer, I., Nadolski, R., Riedel, J.C.K.H., Moreno-Ger, P., Bellotti, F., Lim, T. and Ritchie, J. (2014b), "Study Design and Data Gathering Guide for Serious Games' Evaluation", in Connolly, T.M., Hainey, T., Boyle, E., Baxter, G. and Moreno-Ger, P. (Eds.), Psychology, Pedagogy, and Assessment in Serious Games, Advances in Game-Based Learning (AGBL) Book Series, Information Science Reference, Hershey, Pennsylvania, pp. 394–419.

[6]   Baalsrud Hauge, J. and Bratziotis, C. (2013), "Improving the Understanding of on Supply Chain Interaction among Post Graduate Students through the Application of a Business Game. A Pilot Study", in Pawar, K.S. and Rogers, H. (Eds.), Proceedings of the 18th International Symposium on Logistics (ISL 2013): Resilient supply chains in an uncertain environment: Vienna, Austria 7-10th July 2013, Nottingham University Business School, Nottingham.

[7]   Baalsrud Hauge, J. and Rust, A. (2012), "Using Serious Games for Overcoming Separation between Theory and Practice in the Education of Engineers", in Cunningham, P. and Cunningham, M. (Eds.), eChallenges 2012: Conference, 17-19 October 2012, Lisbon, Portugal, IIMC, [S. l.].

[8]   Gee, J.P. (2003), "What video games have to teach us about learning and literacy", Computers in Entertainment, Vol. 1 No. 1, pp. 1–4.

[9]   Georgiadis, P. and Athanasiou, E. (2013), "Flexible long-term capacity planning in closed-loop supply chains with remanufacturing", European Journal of Operational Research, Vol. 225 No. 1, pp. 44–58.

[10]   Gravier, M.J. and Farris, M.T. (2008), "An analysis of logistics pedagogical literature. Past and future trends in curriculum, content, and pedagogy", Int Jrnl Logistics Management, Vol. 19 No. 2, pp. 233–253.

[11]   Guide, D.R. and van Wassenhove, L. (2008), The evolution of Closed-Loop Supply Chain Research, Faculty & Research Working Paper, Fontainebleau.

[12]   Jayaraman, V., Patterson, R.A. and Rolland, E. (2003), "The design of reverse distribution networks: Models and solution procedures", European Journal of Operational Research, Vol. 150 No. 1, pp. 128–149.

[13]   Kolb, A.Y. and Kolb, D.A. (2005), "Learning Styles and Learning Spaces. Enhancing Experiential Learning in Higher Education", Academy of Management Learning & Education, Vol. 4 No. 2, pp. 193–212.

[14]   Kolb, D.A. (1984), Experiential Learning: Experience as the Source of Learning and Development, Prentice-Hall, Englewood Cliffs, New Jersey.

[15]   Krathwohl, D.R. (2002), "A Revision of Bloom's Taxonomy: An Overview", Theory Into Practice, Vol. 41 No. 4, pp. 212–218.

[16]   Luccini, M., LUCCINI, A.M., Mortarta, M., CATALANO, C.E. and ROMERO, M. (2012), Thematic Application fields report: Deliverable 3.2 of the Games and Learning (GaLA) Network of Excellence.

[17]   Östlin, J., Sundin, E. and Björkman, M. (2009), "Product life-cycle implications for remanufacturing strategies", Journal of Cleaner Production, Vol. 17 No. 11, pp. 999–1009.

[18]   Raybourn, E.M. (2007), "Applying simulation experience design methods to creating serious game-based adaptive training systems", Interacting with Computers, Vol. 19 No. 2, pp. 206–214.

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[19]   Riedel, J. and Baalsrud Hauge, J. (2011), "State of the Art of Serious Gaming for Business and Industry", in Thoben, K.-D., Stich, V. and Imtiaz, A. (Eds.), ICE 2011: Proceedings of the 17th International Conference on Concurrent Enterprising, 20-22 June 2011, Aachen, Germany, FIR e. V. at RWTH Aachen, Aachen.

[20]   Swarr, T. (2009), "Societal life cycle assessment – could you repeat the question?", The International Journal of Life Cycle Assessment, Vol. 14 No. 4, pp. 285–289.

[21]   UNEP (2013), Metal Recycling: Opportunities, Limits, Infrastructure: A Report of the Working Group on the Global Metal Flows to the International Resource Panel.

[22]   Zull, J.E. (2004), "The Art of Changing the Brain", Neurological research supports some well-known ideas about teaching, but does it suggest new – even counterintuitive – ideas?, Educational Leadership, Vol. 62 No. 1, pp. 68–72.

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