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

Matthias KALVERKAMP*

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)](image-url)
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

<table>
<thead>
<tr>
<th>Steps</th>
<th>Kolb’s cycle</th>
<th>Methods and Mechanics</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>[Briefing]</td>
<td>Classic knowledge transmission</td>
</tr>
<tr>
<td>1</td>
<td>Concrete experience (game play)</td>
<td>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)</td>
</tr>
<tr>
<td>2</td>
<td>Reflective observation</td>
<td>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.</td>
</tr>
<tr>
<td>3</td>
<td>Abstract conceptualization</td>
<td>An initial conceptualization starts already during the game play. Afterwards, the students analyse applied theoretical knowledge and the according outcome (alignment 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.</td>
</tr>
<tr>
<td>4</td>
<td>Active experimentation</td>
<td>Development of a new experiment, i.e. testing the theory; small groups test different theories while in the 2nd experiential session (game play)</td>
</tr>
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</table>

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

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

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.

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References


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