Influence of Learning Styles on the Acceptance of Game Based Learning in Higher Education: Experiences with a Role Playing Simulation Game.

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Abstract: This paper describes a study about the Beer Distribution Game in higher education as part of e-business courses. The Beer Distribution Game is a web based role playing simulation game of a supply chain. The original game was developed by the System Dynamics Group at MIT in the early 1960s. What is usually referred to as “the beer game” has been played all over the world by thousands of people ranging from high school students to chief executive officers and government officials, and it recreates a supply chain from industrial fabrication of the product to distribution. The simulation illustrates the building up and reinforcing processes of demand fluctuations within the supply chains. Simulations have proved to be very effective instructional techniques because learners cope with a model as if they were confronted with real life experiences.

The present study is based on a survey of specified groups of students from two European universities. Based on Kolb´s (1984) experience based learning model the different learning styles of student participants were investigated and compared with their attitudes to game based learning in general and the beer game in particular. Students described how playing of the beer game helped them to understand the processes within supply chains and the important role of readily available information to manage these processes. Moreover, the study examined the learning success of students regarding their knowledge about dynamic systems and problems of the supply chains.

Keywords: Problem Based Learning, Learning Styles, Role Playing Simulation Game, Beer Game, Bullwhip Effect, Business Education.

1. Research approach and study design

In business education it is a learning target to teach students how they can manage a complex dynamic system. Especially in higher education those management skills are part of the curriculum. Managing today’s multi-actor systems, such as supply chains, is becoming an increasingly challenging task. To teach students in such topics with a game based teaching approach various levels of outcome and satisfaction are usually recognised. Not all students are able to profit from such a setup similarly. In literature a lot of surveys investigated the general use and outcome in game based scenarios but did not consider the existing diversity of participating persons.

Objective of the preferentially quantitative empirical study was to analyse if different learning types vary in learning outcomes and valuation while using a game based simulation scenario. Estimating a significant imbalance a second motivation was to detect how different learning settings can be created to serve different learning types properly to assure an adequate learning outcome.

Creating a game based learning experience for management decisions in complex dynamic systems (chap. 2.1) a highly developed and widely used role-playing simulation game was selected for the study, the beer distribution game (chap. 2.2).

To differentiate learning styles in our samples Kolb´s (1984) experience based learning model was applied (chap. 3). To test general learning outcomes two comparison groups were additionally created and audited: players and non players. Results of examination performance measurement and online questionnaire are summarized and interpreted particularly in chapter 4.

2. Supply chains and the beer distribution game

2.1 Supply chain management in education

A supply chain is a complex system that involves multiple entities encompassing activities of moving goods and adding value from the raw material stage to the final delivery stage. Its primary object is to satisfy the needs of consumers and finally to generate profits for the supplier. Along the chain there are various types of uncertainties, e.g., uncertainties in production, demand and delivery. Each stage of the supply chain performs a different process and must interact with all other stages in the supply chain (O´Donnell et al. 2006). The supply chain activities begin with a customer order and end when a satisfied customer has paid his or her purchase.

Supply chain management is an example of a dynamic decision task that involves lagged feedbacks and multiple dependent decision makers. This task is known to be difficult for several reasons. According to Sterman (1989), it is difficult for decision makers to control the dynamics of decisions with indirect and delayed feedback effects. Moreover, multiple agents are involved in the process, whose performance depends on the quality of other supply chain members' decisions (Wu et al. 2006).

One additional problem of the supply chain is the bullwhip effect; it is one of the main reasons for inefficiencies in the supply chain. It refers to the observation that a small variance in the demands of the downstream customers may cause a big change in the procurement quantity of upstream suppliers. Forrester discovered that variations of demand (and based on that of orders and stocks) increase up the supply chain from customer to supplier (Forrester 1958). The bullwhip phenomenon refers to the amplifications in orders in a supply chain (see Figure 1). Distorted or late information from one end of the supply chain to the other may lead to inefficiencies, i.e. excessive inventory, quality problems, higher raw-material costs, overtime expenses, shipping costs, poor customer service, inefficient shipment and missed production schedule (Lee et al. 1997). If each distinct entity makes ordering and inventory decisions with an eye to its own interest above those of the chain, stockpiling may be occurring simultaneously at various places (Turban et al. 2010, p. 289).

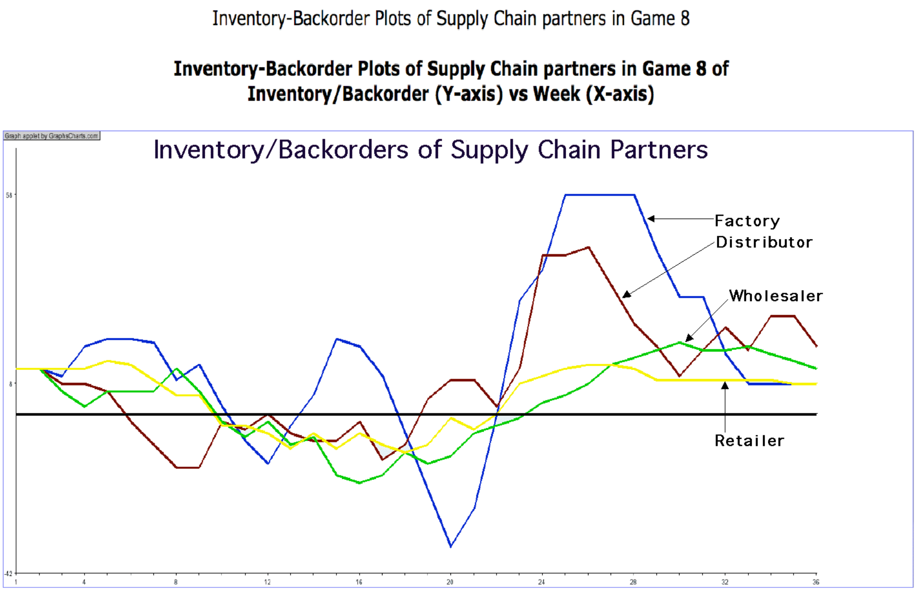

Figure 1: Bullwhip effect: Inventory-Backorder Plot (Beergame TAMU)

Particularly, the bullwhip effect negatively affects a supply chain in three respects (Nienhaus et al. 2006): Dimensioning of capacities, variation in inventory level and a high level of safety stock. To avoid the "sting of the bullwhip" companies take steps to share information along the supply chain. Such information sharing is implemented and facilitates the supply chain management.

2.2 Beer Game

The beer game represents a simplified supply chain consisting of a single retailer who supplies beer to consumers (simulated as an external demand function), a single wholesaler who supplies beer to the retailer, a distributor who supplies the wholesaler, and a factory that brews the beer and supplies the distributor. The beer game is much simpler than real world supply chains. Players have no incentive for forward buying because prices are fixed. Order batching is less likely because the frequency of order placement is fixed to once per week. Rationing is not possible because each facility in the supply chain has only one customer. Finally, in the standard scenario, external consumer demand starts at a constant of 4 barrels of beer per week and then jumps to a constant of 8 barrels per week at the fifth week and remains there for the remainder of what is typically a 52 week scenario. (Martin et al. 2004)

The original Beer Game was a role-playing simulation developed at MIT by Sloan's System Dynamics Group as part of Jay Forrester's research in industrial dynamics of the early 1960's. Jay Forrester conducted research on methodology for integrated analysis and simulation of complex and dynamic systems. The methodology is called system dynamics. Since then, it has been played all over the world by a wide range of participants at all levels, students as well as managers. The classic version of the popular game is a board game.

The production and shipment of the products involve time delays. The same applies to the transmission of orders. The information on the end customer demand is passed on within the supply chain with a delay of one each period of time at each tier.

The rules of the beer game are simple:

- Orders must be filled if there is sufficient inventory
- Unfilled orders are kept in backlog and shall be filled when inventory is sufficient
- Placed orders cannot be cancelled and shipment cannot be returned.

The only decision variable for all supply chain members is the number of units to be ordered in each period. Each supply chain level manages the inventory to minimize holding costs while attempting to avoid out of stock situations. The inventory cost is half of the stock out cost, and there is no sharing of the demand information in the system. Each sector does not know the state of other sectors and decision makers do not know how the time delays and system structure affect the dynamics (Hwarng et al. 2008, p. 1166).

The goal is to minimise the over-all logistics costs of the simulated supply chain. Stock costs 0.5 per barrel per period. If a co-maker cannot deliver, out-of-stock costs of 1 per barrel per period. Thus co-makers have to take into account a trade-off between minimising the cost of capital employed in stocks on the one hand and avoiding of out-of-stock situations, on the other hand.

2.3 Online Beergame Version

Now there are a lot of online beergames available. The study in this paper is based on different online beergames (BWI, Beergame - TAMU) and an online classroom version (Beergame.org). Online games can be used to reduce students' coordination requirements. Coordination activities can distract students from the more important activities that support the game's learning objectives. For example, one of the challenges with the physical Beer Game is simply keeping score. Students make mistakes during the game and sometimes do not get the rules quite right. Online versions of the beergame can practically eliminate such mistakes and speed up games by enforcing the rules, coordinating dynamics and keeping score (Wood 2007).

The differences between the classroom version and a hosted online version of the game affect various aspects. The classroom version is just limited to computers in the same network domain. This limitation makes it impossible to play location independent. Furthermore the server installation and hosting of the classroom version is not accessible for every lecturer. But using the classroom version has also advantages. The animation and graphical support with excellent performance and also some usability issues bring more involvement and fun into the class. It supports easy understanding and learning success to players and convenient control with analysis features to teachers (Figure 2).

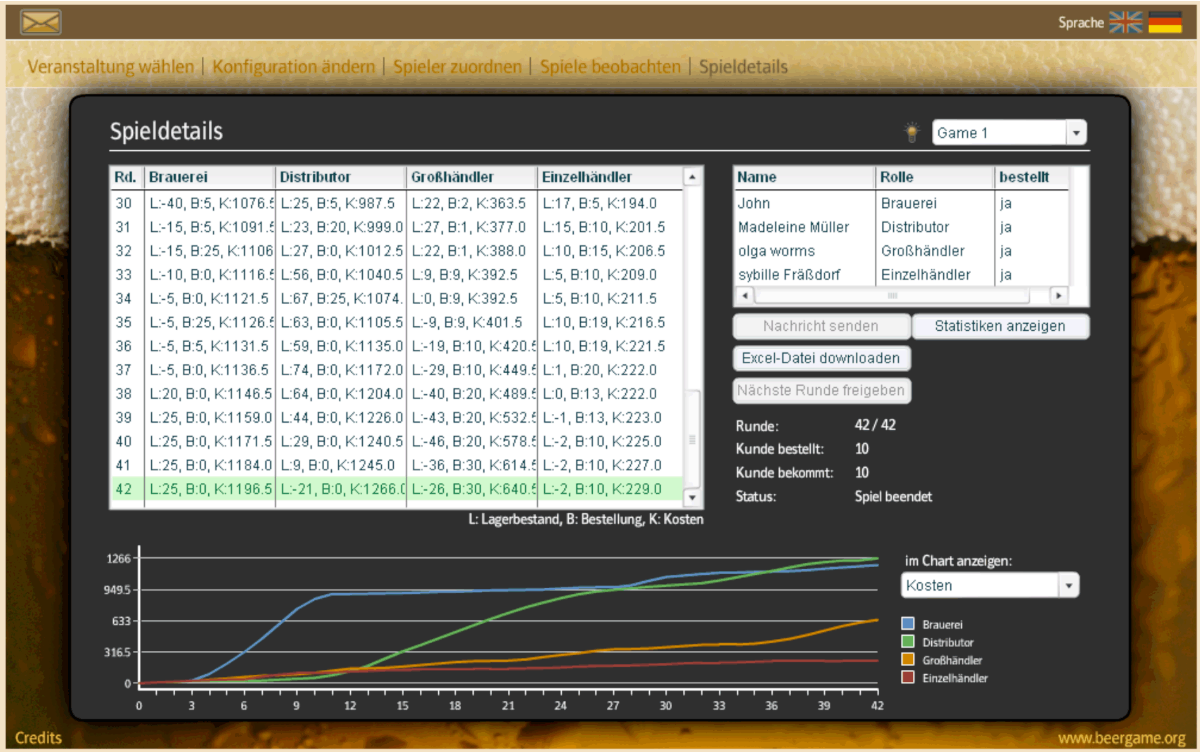

Figure 2: Control and analysis features of the classroom version

However the open online versions of the beergame let students participate outside the classroom. Administration and deployment has not to be organized like in the classroom version. Surprisingly online versions are not that stable and sustainable as expected.

2.4 Playing the Game

At the university in Austria the game was played in two courses, one course with 23 students, in the other course 12 students played the game in class and 8 students played the virtual version. In the phase of debriefing the students exchanged their experiences with the game. The debriefing subsequent to the game was emotional. The students talked about their different behaviour during the game and discussed the different roles within the team. The role of communication was in the centre of attention, both in coordination of the team and for the supply chain. The own behaviour and the behaviour of the team members were not that important in the second group as in group one. In the virtual course the debriefing was conducted by means of a written students report.

At the German university students played the classroom version in six different sessions of 90 minutes. The setting was built to start first a 40 round game with anonymous roles. From the didactic point of view it was important to discuss the results from the first turn and to start a shorter 20 round game with that experience.

3. Learning Model

Simulations are widely used in business education. A simulation game is a mixed feature of a game-competition, cooperation, participants and rules. The underlying didactic design is based on the Experiential Learning Cycle (ELC) developed by Kolb (1984), which has often served as the basic methodological framework of the classic simulation game. In the simulation game the learner is asked to apply his or her knowledge to a complex dynamic situation. A key element is the interaction with the other players. Usually also the complexity of the situation forces the player to take decisions that tend to simulate the decision process of the real world (Fürbringer et al. 2002). Simulations and, even more so, games are entertaining, captivating, provide immediate feedback, and generate motivation among players.

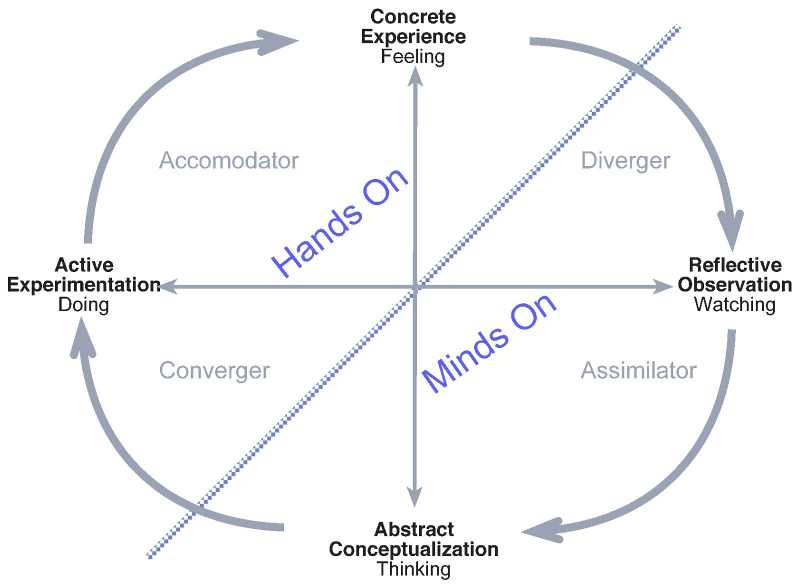

Figure 3: Experiential Learning Cycle (Kolb, 1984)

Despite their differences, researchers in education agree on the existence of various learning styles. But the models differ. One way of approaching the learning needs of students is to use Kolb's (1984) Experiential Learning Cycle as a way of encouraging the development of 'balanced' learning strategies that lead to reflective practice. Kolb´s paradigm of an experience based learning model (Figure 3) is built upon the idea that learning preferences can be described using two continuums: active experimentation - reflective observation and abstract conceptualization - concrete experience. These four elements are the essence of a spiral of learning that can begin with any one of the four elements, but typically begins with a concrete experience. The four stages in this Experiential Learning Cycle include concrete experience – being involved in a new experience, reflective observation – watching others or developing observations about one's own experience, abstract conceptualization – creating theories to explain observations, and active experimentation – using theories to solve problems, make decisions (Beldagli et al, 2010, p. 5755). Simulations have not the objective to substitute formal instructional methods but to serve as a complementary method favouring learning styles other than abstract-reflective. Simulations are a very effective instructional technique because learners experience with a model as if they experience in real life. This brings a new dimension into the teaching-learning process.

Learning can start at any step in the learning cycle with an individual's preference of where to start based on his or her preferred learning style (i.e., diverger, assimilator, converger, accommodator); however, learning is most effective when all four steps are completed. People tend to have a preferred learning style, they learn more effectively if they have access to learning resources that utilize their preferred learning style. Students tend to be frustrated, if the only learning opportunities available to them do not allow using their preferred learning style. For example, an "accommodator" learning style needs to get hands on experience quickly and thus will rebel against instructions and rules. Games and simulations are a good opportunity for those learners to get "hands on" the learning content. An "assimilator" prefers thinking; he or she has a cognitive approach to the content and likes organized and structured lectures. Divergers take experiences and think deeply about them, the simulation is a possibility to gain experiences; the phase of debriefing and reflecting after the game is essential for their learning process. The convergers prefer to think about things and like facts; they try out their ideas in practice, the simulation allows this.

A rich set of activities within a course should be planned to address the best learning mode. It is also important to expose students to their less preferred style as long as they have to develop learning skills in any mode. The term "teaching around the cycle" was coined to describe this instructional approach, where the cycle is a reference to a graphical representation of Kolb's learning styles, as in Figure 3. Kolb created the Learning Style Inventory (LSI) as an educational tool to increase individuals' understanding of the process of learning from experience and their unique individual approach to learning on the one hand and to provide a research tool for investigating experiential learning theory (ELT) and the characteristics of individual learning styles on the other hand. "The LSI is not a criterion-referenced test and is not intended for use to predict behavior for purposes of selection, placement, job assignment, or selective treatment." (Kolb et al. 2005, p. 8)

The LSI is constructed as a self-assessment exercise and a tool for construct validation of ELT. In our study we used an online questionnaire in the learning management system Moodle. The questions followed the learning style diagnostic of Haller/Nowak (1999).

4. Experimental results

The students of three courses (two in Austria, one in Germany) played the beergame. 84 students answered the online questionnaire to the beergame, 60 students (33 female, 27 male) answered the questionnaire to identify Kolb´s learning style, see **Figure 4.**

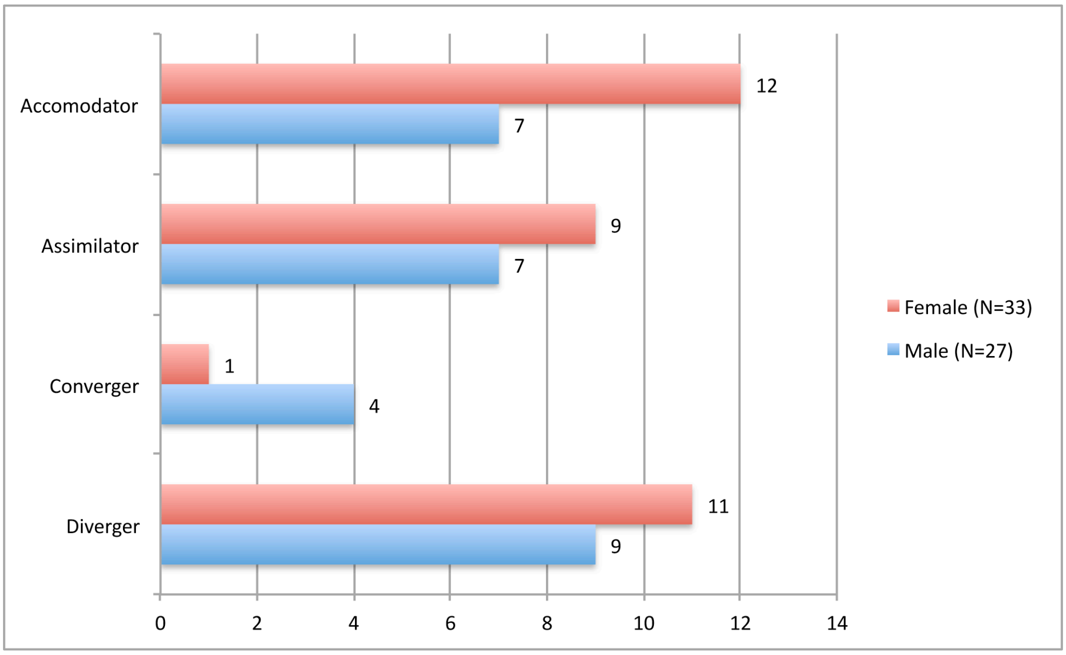

Figure 4: Learning Style and Gender

The data of learning success was collected from the course at the German university only to get a clean comparison between identical learning groups without other influences than participation in beergame or not (comparison group). The exam question concerning the beergame and supply chain management methods concentrated on understanding the Bullwhip Effect. Surprisingly there is only a narrow difference in the scores of exams between 72 participants and 50 non participants (see Figure 5). The advantages of the beergame did not result in significant higher scores in our involved groups as expected. So this study could not proof a substantial benefit of learning efficiency using a Game Based Learning set. For instance also Hainey et al. 2011 came to critical results comparing their own and other studies about efficiency evaluations (p. 33).

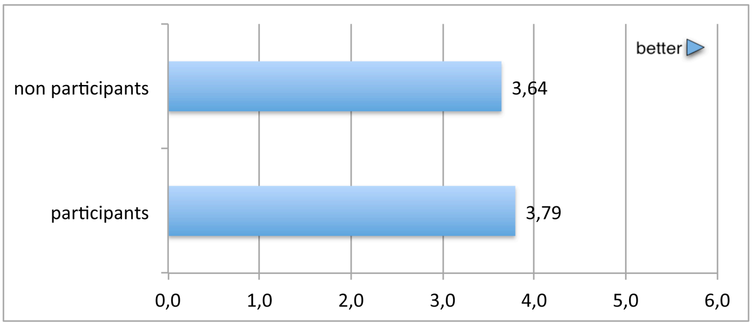

Figure 5: Beergame Learning Success, participants vs. non participants, n=122

To get a different view on how different learning types can be empowered by game based aproaches the study measured learning outcomes in relation to learning styles with the same exam test above (see Figure 6). Assimilators got here best results from written examination questions. This learning type prefers well structured lectures and respects the knowledge of experts. The learning style of the assimilators fit to learning processes in higher education.

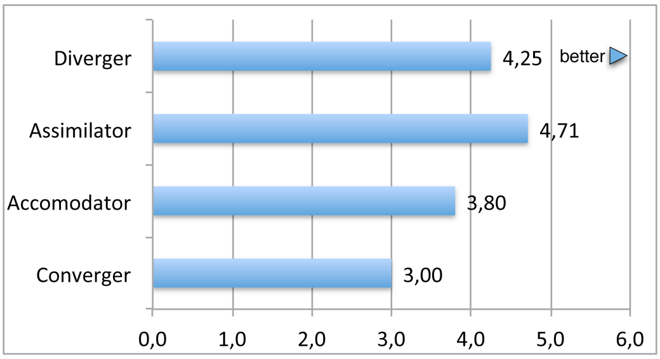

Figure 6: Learning success of the game measured at written examination (n=30)

Beside exam tests and learning outcomes the focus of this study lies primarily on the online feedback of the students. To proof the instructional design of a learning scenario for different groups, participants were asked about their previous knowledge and if this helped them to solve the tasks within game (Figure 7). Previous knowledge especially supported convergers with their engineer-like thinking: »nothing is as practical as a good theory« (Lewin 1951). A scenario with a theoretical introduction first will support especially convergers, but probably other groups not that much. This conclusion corresponds with lecturers experience in other teaching cases where most students rather prefer to start creating something to receiving theoretical introductions first. The minor group of students in this situation – active listening to the theories – are probably convergers.

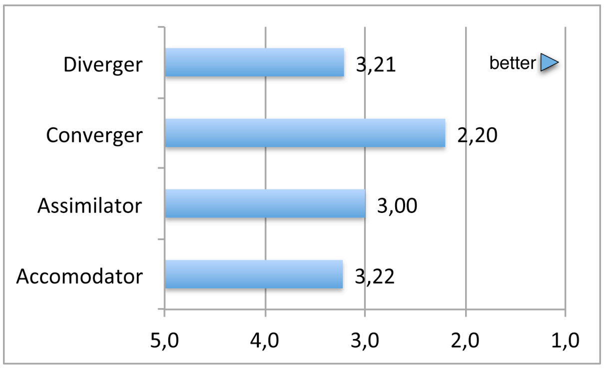

Figure 7: Previous course knowledge was helpful

Concerning the entertainment value of the game Figure 8 shows an oppositional picture. Convergers seem to be less interested in edutainment value than other groups. Obviously the entertainment factor is a very high rated aspect in nearly every game based learning scenario (Prensky 2001, pp 4-6). So relatively high rating in this realm follows the main stream.

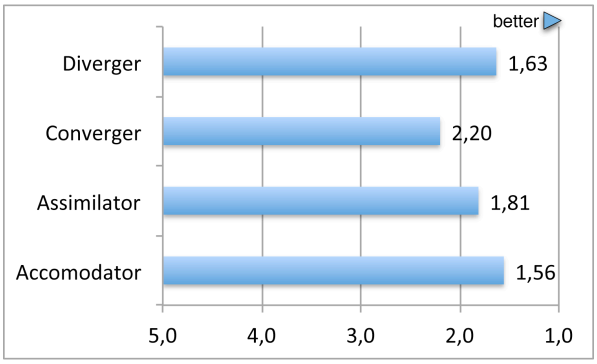

Figure 8: Entertainment value

Figure 9 shows that the assimilators were emotionally involved. The control question for dissatisfaction showed a similar result. The differences between the groups were unincisive. In general the students were satisfied with the game.

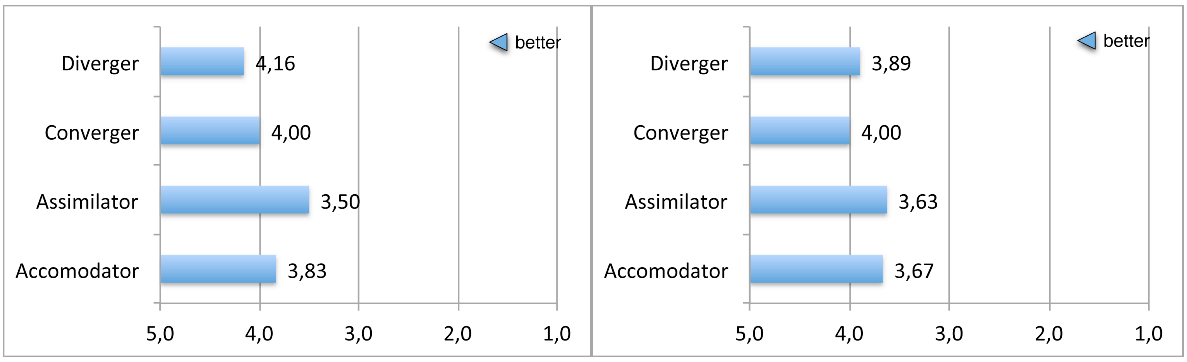

Figure 9: Emotional concernment, dissatisfaction

The special position of convergers in this study also became visible by means of clustering answers into topic groups as in Figure 10. For each of the six topics work interaction, role of information, emotion and negative emotions, the role of previous knowledge and the personal learning process more than one question was developed for the survey in order to obtain a detailed and unambiguous assessment. Related answers of two or three relating questions were clustered into groups.

The significantly higher preference for information flow and knowledge aspects in the convergers group makes it easier for instructors to support this group of students with a didactically motivated setting in a traditional way, with a theoretical introduction at the start and a reflection of theory and practice at the end of a game session. Because this was by coincidence actually the practiced setting at this survey, convergers probably rated the valuation of the game best of all groups (Figure 11). On the other hand without a theoretical steering of convergers these group will probably run rather into dissatisfaction than others.

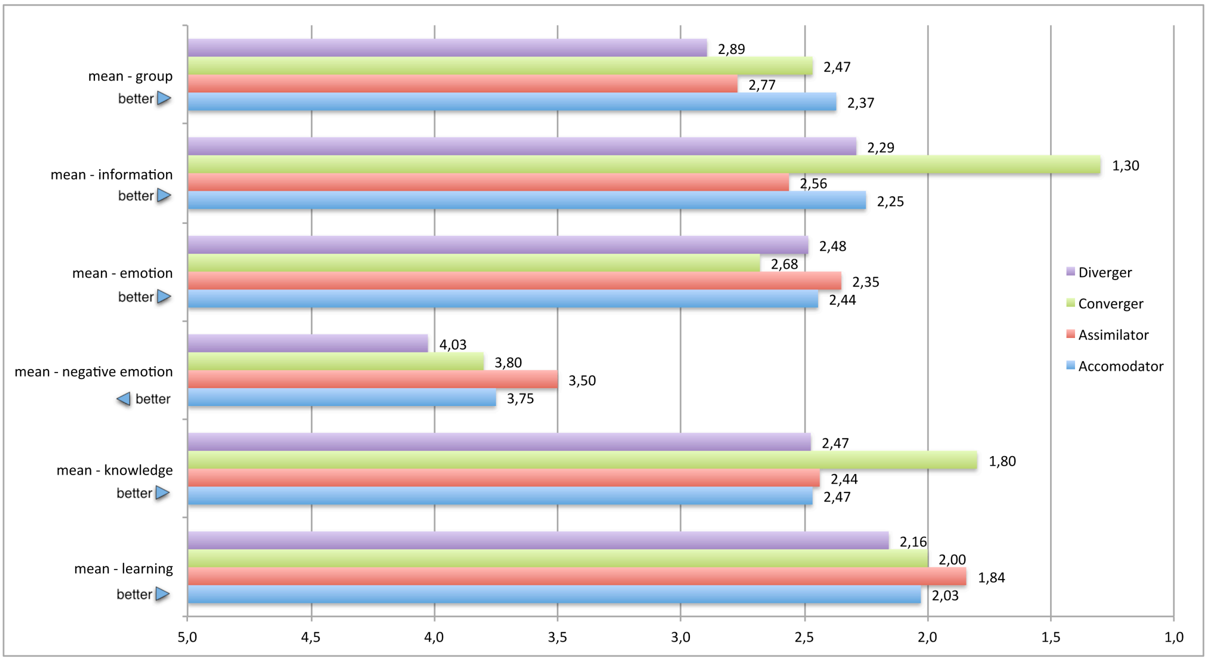

Figure 10: Learning style cluster

In general the students rated the beergame with very good or good marks (see Figure 11). The beergame was a successful learning process. As a learning outcome the students gained knowledge about the bullwhip effect and the problems of dynamic systems. The convergers rated the learning outcome best. The students also rated the beergame very good and good, considering it as an enriching learning method and they would also recommend the game to other students. The assimilators rated it best as varied learning method.

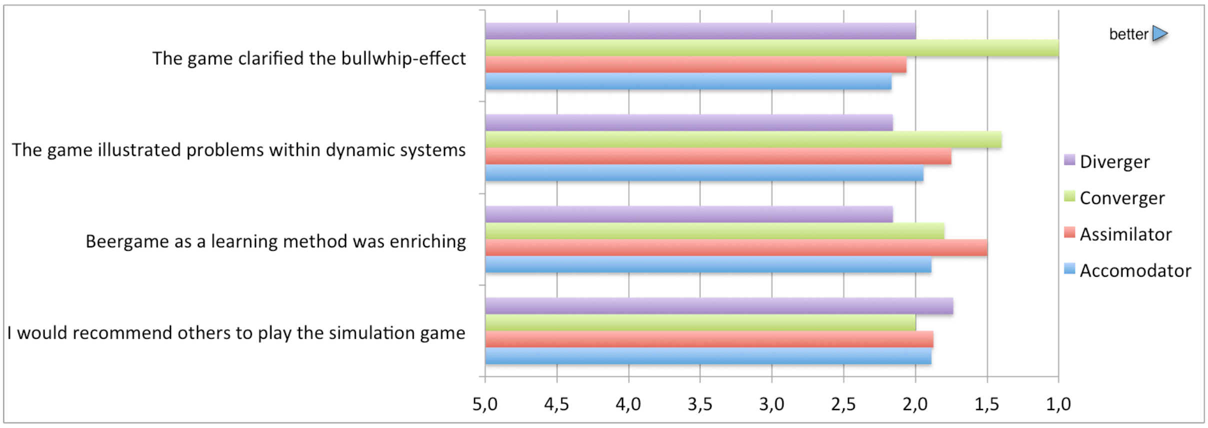

Figure 11: Aspect rating of the game

5. Conclusions

In sum the present study showed that in some cases different learning styles produce significantly different results in game based learning situations, and it is thus efficacious to consider this dissimilarity in the design of learning scenarios. This can be principally used to manage student's diversity with different teaching methods.

However, the differentiation of learning styles with Kolb's LSI using the diagnostics of Haller/Nowak (1999) appears not to be as selective as expected. The correlation of learning styles to learning outcome was not conclusive. The validity of this test was not verified whereby the clear separation of learning types may have been misleading. It was, however, possible to glean results from the data. For instance, the special role of convergers was detected in comparison to other defined learning groups. In future research it will be necessary to show that the testing methods are selective enough.

It is to be conjectured that convergers rated most aspects of this survey best, because the applied didactical setting most suited their learning style: Theoretical introduction – game play – reflection – replay – debriefing. A simulation enables convergers to take full advantage of their approach to learning: Thinking about concepts and linking facts; trying out ideas in practice.

Taking adequate time for the last phase of exercise, the debriefing and discussion of the results appears to be important to all learning groups. The decision and group dynamics portion seem to be key for the learning process.

The feedback from all types of students about the game was generally positive. They particularly welcomed different teaching methods. In university level courses opportunities for experimental learning are relatively rare, game based simulation approaches provide serious yet interesting alternatives.

References

Beergame – TAMU: Texas A&M University, http://davinci.tamu.edu/beergame/v1 (2011-03-22).

Beergame.org: Special thanks to Riemer, K. for the permission to play the beergame. http://www.beergame.org. (2011-03-22)

Beldagli, B. and Adiguzul, T. (2010) "Illustrating an ideal adaptive e-learning: A conceptual framework", *Procedia Social and Behavioral Sciences*, 2 (2010), pp 5755–5761

Centre for Enterprise Sciences (BWI), Swiss Federal Institute of Technology, (ETH) Zurich, The Beer Distribution Game online, http://www.beergame.lim.ethz.ch (2011-03-22)

Forrester, J. W. (1958) "Industrial Dynamics. A major breakthrough for decision makers", *Harvard Business Review*, Vol 36 (1958) 4, pp 37-66.

Fürbringer, J.-M., Freund, P., Glardon, R., Nienhaus, J. and Stammbach, M. (2002) “Pilot modules of OPESS – an online course on operations management, ERP- and SCM systems”, *International Conference on Engineering Education*, August 18 – 21, 2002, Manchester, U.K.

Haller, H. and Nowack, I. (1999) “Lernstildiagnose.” Pädagogisches Seminar. Arbeitsblätter. Göttingen. www.kvhs-osterode.de/.../Lernstilinventar%20KOLB.pdf, (2010-10-27)

Hainey, T., Conolly, T., Stansfield, M., Boyle, E. (2011): “Evaluation of a game to teach requirements collection and analysis in software engineering at tertiary education level.” *Computers & Education* volume 56, issue 1, January 2011, Pages 21-35

Hwarng, B. H. and Xie, N. (2008) “Understanding supply chain dynamics: A chaos perspective”, *European Journal of Operational Research*, Vol 184, Issue 3, 1 February 2008, pp 1163-1178.

Kolb, D. A. (1984) Experiential Learning: Experience as the Source of Learning and Development, Prentice-Hall, Inc., Englewood Cliffs, N.J.

Kolb, A. Y. and Kolb, D. A. (2005). “The Kolb Learning Style Inventory” — Version 3.1 2005 Technical Specifications. Case Western Reserve University. Boston, MA, Hay Group, Hay Resources Direct.

Lee, H.L., Padmanabhan, V. and Whang, S. (1997) “The bullwhip effect in supply chains” *MIT Sloan Management Review*, Spring 1997, 38(3), pp 93-102.

Lewin, K. (1951). “Problems of Research in Social Psychology”, in: *Field Theory in Social Science*; Selected Theoretical Papers, D. Cartwright (Ed.), Harper & Row, New York 1951. p. 169

Martin, M. K., Gonzalez, C.and Lebiere, C. (2004) . “Learning to make decisions in dynamic environments: ACT-R Plays the beer game,” *Proceedings of the sixth International Conference on Cognitive Modeling* (pp. 178-183). Pittsburgh, PA: Carnegie Mellon University/University of Pittsburgh.

Nienhaus, J., Ziegenbein, A., and Schoensleben P. (2006) “How human behaviour amplifies the bullwhip effect,.” A study based on the beer distribution game online, *Production Planning & Control*, Vol.17, No 6, pp 547-557.

O´Donnel, T., Maguire, L., McIvor, R. and Humphreys, P. (2006) “Minimizing the bullwhip effect in a supply chain using genetic algorithms”, *International Journal of Production Research*, Vol. 44, No 8, 15 April 2006, pp 1523 – 1543.

Prensky, M. (2001) *Digital Game-Based Learning*, McGraw-Hill, 2001

Sterman, J. (1989) “Modelling managerial behaviour: misperceptions of feedback in a dynamic decision making experiment”, *Management Science*, Vol. 35, pp 321–339.

Turban, E., King, J., McKay, J., Marshall, P., Lee, J. and Viehland, D. (2010) *Electronic Commerce 2010: A Managerial Perspective*, 6th Edition, Prentice Hall, Upper Saddle River, NJ.

Wood, S. C. (2007) “Online Games to Teach Operations” *INFORMS Transactions on Education*, Vol. 8, No 1, September 2007, pp 3-9.

Wu, D. Y. and Katok, E. (2006) “Learning, communication, and the bullwhip effect”, *Journal of Operations Management*, Vol. 24 (2006), pp 839–850.