Towards a Brewery Educational Game: Would Existence of a Game Goal Improve Learning?

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Abstract. One useful but neglected approach to investigating instructional effectiveness of digital games is to manipulate presence of a game element and compare how the game with and without the element promote learning. In this work-in-progress paper, we introduce a comparative study we are preparing on investigating whether presence of a motivating game goal has a positive effect on learning gains. We also present a brewery simulation/game, which we have developed for the study's purpose. The simulation is the same as the game and contains the same educational materials, but it lacks an explicit game goal: the learners acquire a mental model of the beer production in both applications, but the learning process is "gamified" in the game. We believe that this research approach could help to identify useful features of educational applications.

1 Introduction

It has been argued that digital games can bring many advantages as educational aids, e.g. [5, 10]; however, empirical studies substantiating these claims remain limited and tend to generate mixed results, e.g. [1, 2, 6, 9, but also 11]. In addition, many of these studies, most notably comparative ones, are designed to answer the question whether the digital game based learning approach (DGBL) outperforms so-called "traditional" teaching methods. That complicates generalization of results because a "traditional" method used for a comparison often differs from an employed DGBL method in several dimensions, each of which can influence the learning outcome in either way.

A complementary approach to investigating instructional effectiveness of DGBL is to focus on game elements instead of whole games and ask a question what game features have the highest potential to promote learning. Isolating these features could help developers to develop more instructionally effective games. In comparative "feature isolating" studies, e.g. [9], different versions of a game are compared against each other, and the versions differ in just one or two elements. Similar approach has brought fruits in the close field of multimedia learning [8].

The goal of this work-in-progress paper is to present our brewery simulation/game, designed for the purpose of investigating instructional effectiveness of existence of a game goal and introduce our on-going study on this topic. Games are arguably most fun to play when the goal is personally meaningful and reasonably challenging, cf. [7]. One can hypothesize that that increases engagement of a player and that, in turn, cognitive processing of the player, which, in case of an edu-game, may increase

learning gains. At the same time, the gaming activities may compromise learning by distracting the learner's attention from the learning, a trade-off, cf. [9]. In Netlogo toolkit [12], we have developed an interactive simulation of the process of brewing, in which a learner acquires the mental model of the beer production. The learner can set various parameters at various points during the brewing process, influencing the outcome. The program has two versions: while the first is merely a simulation, the second is presented as a game in which the player can sell the beer, improve the brewery and buy better ingredients such as better yeast. Both versions have nearly the same interface (Fig. 1) and exactly the same supplementary instructions. Would the learning gains be higher for learners working with the game as opposed to learners working with the simulation? Note the application is not a "drill-and-practice" tool; the learning happens during interfacing with the simulated brewery.

The paper proceeds as follows: in Sec. 2, we introduce the process of brewing as modelled by our simulation. In Sec. 3, we detail the simulation and the study.

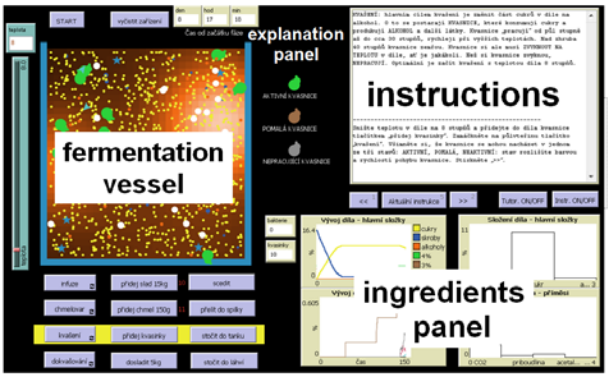

Fig. 1. Brewery simulation screenshot.

2 Process of Brewing

The process of beer-brewing is a rather complicated one as in the beer there were isolated around 2 000 chemical compounds [4]. Thus we focused only on the main topics that can be used, for example, as the first step by a homebrewer and we focused only on the technology for bottom-fermented lagers of pilsner type. We omitted all the processes that can be outsourced (without loss of quality), like malted barley preparation. In general, our aim was to keep the whole simulation reasonably complex for an educational experiment, i.e. neither too short, nor too long.

To briefly describe the process, it consists of mashing, lautering, boiling, whirlpooling, wort cooling, (cool) fermenting and conditioning. As lautering and whirlpooling are simple procedures which one intuitively passes correctly (with an appropriate technology), we focused on the remaining ones only. Also filtering and packaging are not simulated. The mashing got simplified and thus we implemented the infusion mashing. The boiling process is restricted to the hops-addition. The fermentation and conditioning tries to simulate the life of the yeast in the wort.

We focused on typical points in each of the procedures, during which an error can be made, and knowledge of which can be tested easily. During the infusion we simulate how the enzymes in the malt are breaking down the starch into sugars (one "universal" sugar) with respect to the temperature. During the boiling we check just whether it lasts suitably long and how the hops-addition corresponds to a particular recipe. During the fermentation the yeast (*Saccharomyces cerevisiae*) reacts sugars to the alcohol and other chemicals (fusel). We simulate the activity of yeast with respect to the temperature, including the yeast's thermal shocks and change of its metabolism. We simulate also a parasitic bacteria falling into the fermentation tank (*Clostridium acetobutylicum*). From the yeast's by-products we focus only on ethanol, CO_2 and generic fusel. For the bacteria we focus on the acetone. During the conditioning a slight change of taste should take place. This moment we omit but it does not matter too much as we simulate the concentration of CO_2 (whose absence causes for a beer an adequate penalty) and the fusel concentration (which increases if the yeast produce CO_2 too quickly). Before the conditioning it is possible to make a sugar-surrogation.

3 Study on Instructional Effectiveness of a Game Goal Presence

The application models the brewing process as described in Sec. 2 and it has been developed using Netlogo toolkit [12] solely for research purposes. The application has two versions: a) an interactive simulation; b) a single-player game in which the player can sell the beer and improve his/her brewery by earnings from selling the beer.

There are many ways how a simulation can be "gamified" by adding a goal, and many of these ways can actually compromise learning [9]. Our first aim is to develop a game so that it instructionally more effective than the simulation, and only later pinpoint instructional effectiveness of various game goal types. Why have we chosen the brewing process? Brewing beer is a source of a national pride and a personally meaningful task for many Czechs. In addition, many people actually do not know how to brew beer and low previous knowledge can be expected.

For the study, we aim at employing between-subjects design with immediate and delayed post-tests (with over 18 years old subjects). Besides manipulating presence of the game goal, a third, "non-computer" group will be employed. Our plan is that in both research groups, the learners will first go through a tutorial (10 minutes), then proceed to "walk-through" the whole brewing process and inspect its branches (50 minutes), and finally, after a break, will be either assigned a task to brew several types of beers from a fixed list (simulation group) or proceed to the game on improving the brewery, in which they will brew the same types of beers as they would do in the simulation group (game group) (30 minutes). Learners in the non-computer group will study paper materials combining the simulation images and instructions (60 minutes) and participate in worksheet activities concerning the topic (30 minutes). In each group, the learners will be exposed to the materials for 90 minutes. All the groups' participants will work with the same texts and images during the whole study and have the same tasks for the last 30 minutes.

We have already conducted a feasibility study with 16 subjects, which helped us to refine the simulation and instructions. This study pinpointed one possible problem, the duration of the intervention: the initial exposure of 60 minutes is long for some

learners. The open question is how many materials should be removed: the more we remove, the worse mental model of the process can be expected to be acquired.

Concerning the knowledge tests, we aim at employing Mayer's type of retention and problem-solving transfer tests [8], which we are presently piloting.

4 Conclusion

We have introduced an educational study we are currently preparing on investigating whether an interactive simulation is instructionally more effective if an explicit goal "gamifying" the learning content is added (and in a more remote future, what kind of goal should be added to maximize learning gains). Although our research question may seem trivial, empirical results elucidating this issue are very limited. For the study's purpose, we have already developed a brewery simulation/game and we are currently piloting the study. The application is not a "drill-and-practice" instructional program in which the learning part is separated from the gaming part; learners should learn directly when interfacing with the application.

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References

1. Brom, C., Preuss, M., Klement, D.: Are Educational Computer Micro-Games Engaging And Effective For Knowledge Acquisition At High-Schools? A Quasi-Experimental Study. In Computers & Education 57 (2011) 1971-1988
2. Clark, R., et al.: An Analysis of the Failure of Electronic Media and Discovery-based Learning: Evidence for the Performance Benefits of Guided Training Methods. In: Handbook of Training and Improving Workplace Performance, Vol. I: Instructional Design and Training Delivery. Somerset, NJ: Wiley (2009) 263-297
3. Egenfeldt-Nielsen, S.: Beyond Edutainment: Exploring the Educational Potential of Computer Games. PhD thesis. University of Copenhagen. (2005)
4. Esslinger, H.M. (ed.): Handbook of Brewing: Processes, Technology, Markets, Wiley (2009)
5. Gee, J. P.: What video games have to teach us about learning and literacy. New York: Palgrave/St. Martin's (2003)
6. Hays, R. T.: The Effectiveness of Instructional Games: A Literature Review and Discussion, Technical Report 2005-004, Orlando: Naval Air Warfare Center Training Systems Division (2005)
7. Malone, T. W.: Toward a theory of intrinsically motivating instruction. Cognitive Science 5(4) (1981) 333-369.
8. Mayer, R. E.: Multimedia learning. New York: Cambridge University Press (2001)
9. Mayer, R.E., Clark, R.C.: Simulations and Games in e-Learning. In: E-Learning and the Science of Instruction, 3rd. ed., Chap. 16, John Wiley & Sons (2011) 369-400.
10. Prensky, M.: Digital Game-Based Learning. McGraw Hill, New York (2001)
11. Sitzmann, T.: A meta-analytic examination of the instructional effectiveness of computer-based simulation games. In Personnel Psychology 64 (2011) 489-528
12. Wilensky, U.: NetLogo, Center for Connected Learning and Computer-Based Modeling. Northwestern University (1999) available: http://ccl.northwestern.edu/netlogo/ [Accessed 11.3.2012].