Developing a Serious Game for Business Information Visualization

Emergent Research Forum Paper

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Abstract

Business information visualization (BIV) is increasingly recognized by companies as being essential to avoid threats and realize opportunities. However, many companies still do not seem to know how to improve their BIV. Serious games appear to be a promising approach to convey this knowledge. To investigate the question whether using serious games to improve BIV skills is beneficial, they should be empirically evaluated. However, we could not identify such games in our literature review. The main goal of this study is therefore to fill this gap by contributing a serious game that aims to improve players' BIV skills. Within the game, players compete across several minigames that each address one specific guideline for achieving adequate BIV. A software prototype of the game is developed using the human-centred design process. After its development will have finished, areas of application and evaluation will include education as well as employee training in companies.

Keywords

Business Information Visualization, Serious Games, Game-based Learning, International Business Communication Standards, Design Science Research.

Introduction

Business information visualization (BIV) is increasingly recognized by companies as being essential to avoid threats and realize opportunities (Evelson and Yuhanna 2012). By effectively using BIV, companies may reduce wrong decisions caused by incomprehensible or misleading data (Ware 2012). For instance, the accident of the space shuttle Challenger may have been avoided using more appropriate information visualization (Tufte 1997). However, many companies still do not strive for adequate BIV in their management reporting (Al-Kassab et al. 2014). A possible explanation for this is the lack of knowledge about proper visualization practices (Few 2012). Since serious games already foster cognitive learning outcomes in many domains (Connolly et al. 2012; Wouters et al. 2009), they appear to be a promising approach to convey this knowledge. The overarching research question of our project is therefore whether it is beneficial to use serious games that improve players' BIV skills, especially compared to more traditional learning methods (e.g., lectures). To investigate this question, serious games that focus on BIV should be empirically evaluated. However, this evaluation would require that these games have already been developed. Since we could not identify such games in literature, this study sets out to fill this gap first by introducing a serious game that aims to improve players' BIV skills. Hence, the research objective of this study is as follows:

Develop a serious game that improves players' business information visualization skills.

This study conforms to design science research (Hevner et al. 2004) and presents a software prototype as its artifact that emerged from the first iteration of the human-centred design process (ISO 2010). In the following, we will outline the theoretical background and related work as well as the development method. After describing the resulting prototype, the paper closes with a discussion, conclusion, and next steps.

Theoretical Background

Information visualization is defined as "the use of computer-supported, interactive visual representations of abstract data to amplify cognition" (Card et al. 1999). When information visualization technologies are used to visualize business data or information (e.g., with tables or column charts) it is referred to as BIV (Tegarden 1999). A possible approach to improve BIV skills is the use of visualization guidelines that support design decisions and draw on insights from cognitive psychology such as gestalt theory (Ware 2012). Although several guidelines for information visualization exist (e.g., Shneiderman 1996; Tufte 1997; Ware 2012), only few focus on elements used specifically in business reports. One framework that highlights the design of business reports and presentations are the International Business Communication Standards (IBCS) (Hichert and Faisst 2015). This framework comprises specific guidelines that showcase bad examples of BIV alongside their proposed corrections. We will hence incorporate these guidelines in our serious game to enable players to identify inadequate BIV and to suggest reasonable improvements. These two skills, namely being able to identify inadequate BIV and being able to suggest reasonable improvements, are what we refer to as BIV skills in this study. To acquire them, an understanding of the interactions between symbols, shape effects, colors, etc. (Ware 2012) is required which is supposed to be fostered by the guidelines used in our serious game.

In contrast to gamification, where game elements are used in non-game contexts (Deterding et al. 2011), serious games constitute whole games that are not limited to the purpose of entertainment but also focus on improving skills and teaching players educational content (Abt 1987). Since these games aim to improve learning through intrinsic motivation, their theoretical background includes several learning and motivation theories like self-determination theory and flow theory (Grund 2015). One specific theory used to describe player motivation in serious games is tournament theory (Liu et al. 2013). It assumes that competition between equally skilled players increases effort, enjoyment and arousal while playing. Hence, competition will be a central aspect of the serious game developed in this study.

Related Work

Prior to developing a serious game for improving BIV skills, we want to characterize the state of the art of BIV as a learning goal or a learning outcome in serious games. Susi et al. (2007) provide a basic overview of serious games, referring to Michael and Chen (2006) who claim that communication skills (i.e., effectively presenting ideas when speaking, writing, etc.) are important for employees in corporations. Although this might include BIV, this learning goal is not explicitly stated. Connolly et al. (2012) investigate empirical evidence on the learning outcomes of computer games and serious games in a systematic literature review. Out of the 129 publications they identified, 17 higher quality studies report knowledge acquisition and content understanding outcomes. However, none of these studies mention BIV as a learning outcome. Another literature review about the learning outcomes of serious games conducted by Wouters et al. (2009) concludes that cognitive learning outcomes (i.e., knowledge and cognitive skills) can be observed in 12 out of the 28 empirical studies investigated. Although they argue that serious games seem to be effective when it comes to cognitive learning outcomes, BIV was again not a learning goal in any of the studies. In a recent literature review about using serious games to improve the decision process, Grund and Meier (2016) show that BIV is not addressed in their sample of serious games that include business reporting. In summary, according to the investigations mentioned above, a serious game that specifically focuses on improving BIV skills seems to be still missing. We intend to fill this gap with the serious game described in the following sections.

Development Method

Several approaches for developing serious games have been proposed thus far (e.g., de Freitas and Jarvis 2006; Moreno-Ger et al. 2008; Nadolski et al. 2008). Although there does not seem to be an established standard or a thorough evaluation among these development processes, they all concur that for a serious game to be successful, both educational objectives as well as providing an entertaining experience are important. Since the latter can only be evaluated through actual playing, a development process should encompass several iterations of play-testing with prospective users. For this reason, we suggest to employ the human-centred design process specified by ISO (2010) that is prevalent in the domain of human computer interaction (Earthy et al. 2001).

Before going through the design steps of the human-centred design process, the basic structure of the serious game has to be planned. We intend to develop a 2-dimensional game that addresses guidelines for adequate BIV in a competition between players. This competition consists of several minigames that each address one specific guideline. To emphasize the sense of competition, every minigame is loosely based on sports, hence the name "Dashboard Tournament".

As a first design step, the context of use needs to be understood and specified. In our case, the target group consists of university students in a management information systems course about business reporting (i.e., prospective BIV professionals and junior managers). The course already features a tutorial on reporting software in the first week that is delivered in a computer room containing 30 workstations in the same network. Hence, this setting will serve as the context of use for the Dashboard Tournament.

Next, we will specify the user requirements. Users include the organization (i.e., university) as well as the players (i.e., students). From an organizational perspective, it is important that players understand the learning content (i.e., how to improve BIV). From a player perspective, an entertaining experience (e.g., having fun, feeling immersed, etc.) is desirable.

The production of design solutions is twofold: First, guidelines from the IBCS are matched with several game mechanics in a brainstorming session to draft minigames for the Dashboard Tournament. This form of ideation leaves room for creativity while still focusing on the learning content. Second, the drafted minigames are implemented as a software prototype using the Unity game engine.

To evaluate the game against requirements, we conduct semi-structured interviews with play-testers. Interview questions include items from the game experience questionnaire (IJsselsteijn et al. 2008) that cover player requirements. Additional questions aim to assess the understanding of different ways to improve BIV, which addresses organizational requirements. Last, there is space for play-testers to add individual thoughts and suggest improvements.

Software Prototype

The following software prototype resulted from the first iteration of the human-centred design process described above. It comprises four minigames (i.e., sports) that each address one specific guideline for adequate BIV from different perceptual IBCS rule sets (i.e., condense, check, express, and simplify) which are for instance based on gestalt theory (Hichert and Faisst 2015). Since tournament theory suggests that only equally skilled players should compete, the interactions in each minigame are very simple so that for example prior experience with video games is negligible. Players can score between 0 and 100 points per minigame that are displayed in a global leaderboard after finishing. These points serve as a mechanic for achieving motivation, they do not indicate learning success. The game ends when every minigame is finished and the overall winners (i.e., first, second, and third place) are announced. As proposed by Garris et al. (2002), the game is followed by a debriefing session. During debriefing, players exchange their experiences from every minigame and think of implications for improving BIV. This is mainly where learning takes place, i.e. the minigames focus on facilitating experiences that are reflected on during debriefing. The instructor guides the discussion to make sure the corresponding guidelines are addressed. An overview of the minigames implemented in the software prototype is provided in Figure 1.

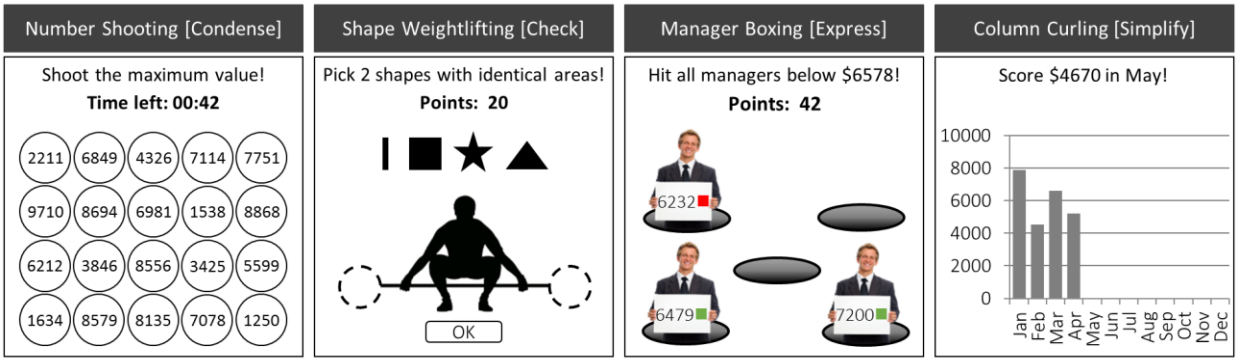

Figure 1: Minigames implemented in the software prototype

The first minigame is called "number shooting" and addresses the guideline CO 4.4 (Hichert and Faisst 2015). This guideline recommends using graphical elements in tables to easily identify differences in size between numbers. The basic layout of the minigame is a grid of targets with numbers (similar to a table) without any graphical support. There is only a limited time for identifying the maximum value and "shooting" it. Hence, players have to compare the numeric value of every target inside the grid, which causes high cognitive effort. After the time has passed or the right target was shot, the minigame ends.

In the second minigame, which is called "shape weightlifting", the guideline CH 3.1 is covered (Hichert and Faisst 2015). This guideline advises against using area comparisons in reports (like it is employed in pie charts) and instead suggests using length comparisons. To experience the difficulty of correctly comparing area sizes, players have to select two shapes with identical areas out of several different shapes and attach them to a weight bar. There are five rounds with decreasing differences between the areas of the shapes, which leads to increasing difficulty.

The next minigame is called "manager boxing" and is concerned with the guideline EX 2.5 (Hichert and Faisst 2015). This guideline disadvises from using traffic light indicators in reports, since they distract from comprehending the actual numbers. To show this effect, players have to hit all managers holding numbers below a given threshold in a "Whac-A-Mole"-style minigame. At the beginning of the minigame, the traffic lights next to the numbers are consistent with the goal (i.e., showing red when the number is below the threshold). However, inconsistencies arise later in the game, leading to wrong decisions when players blindly trust the traffic light indicators.

The last minigame is called "column curling" and addresses the guideline SI 3.1 (Hichert and Faisst 2015). This guideline recommends replacing value axes in column charts with data labels. Initially, players face an empty column chart with a target value displayed for the current month. By holding a key, they can "grow" a column for this month. When the key is released, the resulting column is the estimate for the month and a new target value is set for the next month. In doing so, players experience difficulties when estimating the exact height given only a value axis and gridlines.

Discussion and Conclusion

The software prototype described in this study is a first approach to improve BIV skills with a serious game. Due to its modular structure, minigames can be added or removed in forthcoming iterations of the human-centred design process. Since all minigames only use few interaction types (i.e., clicking and dragging), the game might also be ported to mobile devices. A possible limitation of the approach is the use of leaderboards: While they may motivate high-scoring players, they might also potentially embarrass players who "lose" against their peers. In addition, the presented game is fully digital. Since there are empirical investigations that indicate benefits of non-digital games (e.g., board games), these benefits might not be realized by our approach.

After its development will have finished, the prototype will be thoroughly evaluated in a between-subject experimental design. Participants will be asked to suggest improvements in a business report before and after playing the game. When this evaluation shows that the game leads to better suggestions concerning BIV, especially compared to more traditional learning methods, this might indicate that it is beneficial to use serious games to increase players' BIV skills. These games might then be tested in blended learning scenarios that combine both serious games as well as other learning methods for improving BIV skills. After thorough evaluation, the Dashboard Tournament might be used in several areas of application. First, educators in management information systems courses might want to add this game to their curriculum to improve BIV skills. Second, companies might use it to help employees create adequate reports for example with business intelligence applications. After the game has been adopted in practice, differences between students and practitioners (e.g., acceptance or learning outcomes) may be examined.

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