Projecting Efficacy and Use of Business Simulation Games in the Production Domain Using Technology Acceptance Models

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Abstract Globalized markets, product complexity, and increased requirements on quality lead to growing complexity of business and manufacturing processes. Game-Based learning environments and business simulation games offer great potential to prepare employees the increasing complexity. As it is unclear who profits most from these learning environments, we did a study with 66 participants on a game for conveying Production Planning and Control and Quality Management. In our research model we combined personality attributes and two common technology acceptance models to determine factors projecting performance in the game and projected later use of business simulation games in general. We found that main drivers for usage are performance expectancy and transfer of skill, i.e., the perceived applicability of the learned knowledge and skills for the later work. The attained performance is unrelated to the projected use. The article concludes with guidelines to increase the likelihood for the later use of business simulation games and for increasing their overall efficacy.

Keywords Serious game · Game-based learning · Business simulation game · Production planning and control · Quality management · UTAUT2 · Supply chain management · Technology acceptance · Human factor · System thinking

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C. Schlick and S. Trzcieliński (eds.), *Advances in Ergonomics of Manufacturing: Managing the Enterprise of the Future*, Advances in Intelligent Systems and Computing 490, DOI 10.1007/978-3-319-41697-7_52

1 Introduction

Today's globalized markets are characterized by increasing complexity of cross-national supply chains, growing variant diversity, and rising pace. In order to sustain at the market, manufacturing companies must enhance their competitiveness. Methods to increase the competitiveness include novel products and services, increased efficiency in production and administration, but also smarter personnel that handle the complexity of todays' world more efficiently. One specific area of interest is production planning and control and quality management: While most aspects are rather easy to comprehend when considered individually, the true complexity unfolds in the conjunction of all aspects to be considered.

One necessary skill of tomorrow's decision makers is "*Systems Thinking*": The ability to understand that systems are more than the sum of their parts and that the systems' behavior emerges from the dynamic connections and feedback loops between its parts. Peter Senge defines this as a "*way of thinking about, and a language for describing and understanding, the forces and interrelationships that shape the behavior of systems. This discipline helps us to see how to change systems more effectively, and to act more in tune with the natural processes of the natural and economic world.*" [1]. In fact, Forrester used this methodology to describe the complexity and relationships in production processes using System Dynamics modeling [2].

The important question is, how Systems Thinking can be conveyed to scholars, such as, university students from mechanical engineering and prospective managers in this domain. A prominent methodology is the use of business simulation and serious games. Beyond traditional transmission of knowledge, these environments allow the active exploration of cause-and-effect relationships of complex and interconnected systems in simulated and safe environments. However, it is not sufficiently understood yet, if serious games are preferred over conventional knowledge dissemination forms and which user and system characteristics of serious games contribute to an increased acceptance.

To explore if serious games are appropriate to convey Systems Thinking and to identify the factors that contribute to an increased acceptance of game-based learning, we applied the technology acceptance research methodology on a business simulation game that conveys knowledge of material disposition and quality management.

This article is structured as follows. Section 2 outlines related work in regard to technology acceptance models and serious games. Section 3 presents our experimental approach and the sample of our study. Section 4 presents the findings of this research endeavor. Section 5 discusses the results and their implications for implementing serious games as a teaching method and for developing further serious games. Finally, Sect. 6 addresses the limitations of this study and outlines the future research agenda.

2 Related Work

The following paragraphs introduce technology acceptance research and its models. Afterwards serious games and their application domain are outlined. Finally, serious games from the domain of production engineering are presented.

2.1 Technology Acceptance Models

The goal of technology acceptance research is to predict the active adoption of a technology as well as the likelihood of a technology to be used by people. What is central here is to identify the learners' personality as well as supportive and impeding system factors that govern this adoption, to address these factors through adopted designs, improved training materials, or optimized dissemination strategies.

Many empirical technology acceptance models are rooted in Fishbein and Ajzen's *Theory of Reasoned Action (TRA)* [3] that postulates a strong relationship between the *intention* to do something and the actual *doing*. In this model, as well as in the subsequent technology acceptance models, the intention to use is governed by the attitudes of an individual. In TRA the *intention* to do something is related to the *attitude* and the *subjective norm* of an individual towards the behavior. For example, an individual can like playing games (attitude), which might increase the intention towards serious games, but may consider playing as socially undesirable (*subjective norm*), which would dampen the intention to use serious games.

Based on this model the *Technology Acceptance Model (TAM)* [4] suggests that the intention to use software at the workplace is largely controlled by the *perceived usefulness* and the *perceived ease of use* of the software. The perceived usefulness refers to the perceived benefits of using the software to achieve better results or to achieve results in shorter time. The perceived ease of use captures how usable and how learnable the software is evaluated by an individual. Using this model, about 51 % of the variance in actual use of software could be predicted in advance. The original TAM and many of its successors (e.g., [5, 6]) primarily addressed business software used in work contexts.

A model that specifically aims at predicting the adoption of consumer products with voluntary usage is the *Unified Theory of Acceptance and Use of Technology 2 (UTAUT2)* [7]. It postulates that intention to use is controlled by the seven dimensions *performance expectancy (PE)*, *effort expectancy (EE)*, *social-influence (SI)*, *price-value (PV)*, *hedonic motivation (HM)*, *facilitating conditions (FC),* as well as *habit (HA)*: *Performance expectancy* refers the individual's perceived benefits of using the technology (cf. perceived usefulness in TAM). The *effort expectancy* addresses the perceived effort for learning or using the technology (cf. perceived ease of use). The *social influence* comprises how an individual perceives the reaction of his/her peers regarding the technology. That is, a technology might be judged as beneficial for doing something (*PE*) and easy to use (*EE*), but through negative expectations regarding the social environment (*SI*) it might still not be indented to use. The *price-value* dimension captures that a technology might be perceived as useful, but not worth the money. The *hedonic motivation* addresses that a technology ought to be fun to use, especially when the use of the technology is voluntarily. The *facilitating conditions* capture the environmental and contextual aspects that support or diminish the usage of a technology. For example, the technology must be compatible with other technologies in use or help should be available if difficulties emerge. The last dimension *habit* refers to the individual's perception of integrating the use of the technology in the daily routine.

Another model that specifically addresses serious games is the Serious Games Technology Acceptance Models (SG-TAM) [8]. Despite being still in its infancy, the model builds on the theoretically sound dimensions *Transfer of Skills (TOS)*, *Learner Control (LC)*, *Situated Learning (SL)*, and *Reward (REW)*. *Transfer of Skills* refers to perceived abilities to apply the learned knowledge to other tasks or to a later job. *Learner control* addresses the player's perception of adjusting the game to his or her own pace. *Situated Learning* describes the player's perception of a similarity between the game environment and the real life. Finally, *Reward* records if the players feel that the feedback and positive reinforcement encourages further interaction with the game.

2.2 Serious Games

Michael and Chen [9] define a serious game as "*a game in which education [...] is the primary goal rather than entertainment*". They build on the famous Premack principle [10] to link undesired activities—such as learning, exercising, change attitudes, or behaviors—to pleasant activities—in this case playing. They are very successful in the medical domain, for example for conveying knowledge about a disease [11], for supporting a rehabilitation [12], or for enhancing cognitive control of elderly [13].

Prensky argues that game-based learning environments are a necessity to address the knowledge dissemination needs of Digital Natives, Millennials, and the Generation Y [14]. These generations grew up with ubiquitous information and communication technologies they are not easily attracted by conventional didactical approaches.

2.3 Serious Games for Production Systems

A prominent example for a serious game in production engineering is Forrester's Beer Distribution Game [15, 16] that aims at sensitizing dispatchers and schedulers for the "Bullwhip effect" in supply chains, i.e. that order quantities can quickly escalate along multiple tiers and that sharing point-of-sale information across the supply chain can reduce this effect. Multiple players form a multi-tier market driven supply chain, ordering information flows upstream from the customer, to subsequent tiers, to the factory, whereas the produced goods flow downstream from factory to customer.

Goldratt introduced variances to this kind of business simulation game [17]. In his hypothetical game orders are not fulfilled completely, but capped by a dice toss. He concludes that variances in a supply chain limit their overall performance.

Stiller et al. [7] combined material disposition from the Beer Distribution Game with variances in production quality into the game model *Quality Intelligence Game* (aka. *QI-Game*). In contrast to previous games, players need to balance investments for managing the inventory, incoming goods inspection, as well as investments in the own production quality. Broken and undetected bought-in parts cannot be fixed during the production and the customer detects all defective parts. Thus, missing one of the three key aspects (stock management, quality of incoming goods, own production quality) yields in disastrous performance. Figure 1 illustrates the game's user interface.

In a recent article we compiled four basic methods for using game-based learning environments and business simulation games as empirical and interactive research environments [19]: The various in-game metrics (e.g., company's profit, stock levels, and customer complaints) can be related to gaps in knowledge and identify learning potentials, classify the task fit of job applicants, isolate underlying human-factors relating to performance, and help to critically benchmark user-interface aspects [18]. Serious games are rarely evaluated using formal technology acceptance models. Two of the few examples are the evaluation of a physical exercising game [20] and a game for cognitive functioning [21] in technology-augmented habitats using the before-mentioned UTAUT2 technology acceptance model.

To address this void and to identify factors that are crucial for the use of serious games for knowledge dissemination in quality management, mechanical engineering,

Fig. 1 Illustration of the quality intelligence game (see [18] for details)

and production engineering we applied technology acceptance research on the Quality Intelligence Game in a formal user study. The next section presents our approach.

3 Method

To investigate if business simulation games will be used and which specific aspects promote or undermine the use we conducted a formal experiment using the before mentioned *QI-Game* (see Fig. 1). The following sections describe (1) the experimental procedure, (2) the experimental variables, and (3) the sample's characteristics.

3.1 Experimental Procedure

The interaction with the *QI-Game* is accompanied by a proceeding survey to assess demographics and personality attributes and a subsequent survey to measure the evaluation of the game. Both surveys and the in-game metrics (e.g., attained performance, number of interactions) are linked using a hidden unique identifier. The game is presented in a rather easy setup, meaning that no sudden changes in the supplier's delivery quality or the internal production quality occur (contrary to [18]). The link to the study was distributed through regular and computer-mediated social networks among our students. Hence, we assume that we have addressed mostly university students.

3.2 Investigated Variables

Independent Variables. As independent variables we captured the *age* and *sex* of the participants, as well as three personality traits and states:

Self-efficacy in Interacting with Technology (SET). This construct captures the individual's believe to be able to master technology and to solve technical problems [22]. It is a key variable to predict efficacy, efficiency, and user-satisfaction in interacting with technology. It could therefore relate to the evaluation of and the attained performance in computer-mediated serious games and that people with lower SET scores achieve lower scores and are less inclined towards the game (e.g., [20]).

Attitude Towards Serious Games (ASG). We measured an individuals' attitude towards Serious Games to convey knowledge through four items. This new scale achieved an outstanding internal reliability [Cronbach's $\alpha = 0.917$, 4 items, $n = 66$].

Need for Achievement (NA). This trait refers to the desire and the continuous efforts to achieve difficult goals [23]. We suspect, that NA influences the performance and the intention to use the game to gain a competitive advantage in this domain.

Dependent Variables (Subjective). We measured the seven dimensions from UTAUT2 (see Sect. 2.1). We further included the four dimensions of SG-TAM *Reward*, *Learner Control*, *Transfer of Skills*, and *Situated Learning*. We assume that using serious games is perceived as fun and entertaining, but potentially as less efficient than listening to lectures or reading a reference book. Hence, we also assess the perceived *Time-Value (TV)* tradeoff.

Four items capture the *Intention to Use* serious games (BI) [Cronbach's $\alpha = 0.737$]. This construct is divided into items that address this specific game and serious games for knowledge dissemination in general.

Dependent Variables (Objective). In addition to the subjective measures from above, the game captured several objective metrics through log-files of the game environment: We investigated the influence of the attaint overall performance and the number of changes to the three controllers in the game's user interface (incoming goods inspection, procurement, internal production quality).

Methods. All subjective measures were captured through six-point Likert scales. The data is analyzed with parametrical and non-parametrical methods, using bivariate correlations and multiple linear regressions. The STEPWISE method is used in the multiple linear regressions and models with high variance inflation (VIF $\gg$ 1) are excluded. The type I error rate (level of significance) is set to $\alpha = 0.05$ and findings $0.05 < p < 0.1$ are reported as marginally significant.

3.3 Description of the Sample

66 people aged 20 to 56 years (median 24 years) participated in the experiment (8 female, 57 male, 1 unspecified). Sex was neither associated with Self-efficacy in interacting with technology (SET) [$\rho_{n=64-2} = -0.081$, $p > 0.1$], Need for Achievement (NA) [$\rho_{n=65-2} = -0.084$, $p > 0.1$], nor the Attitude Towards Serious Games (ASG) [$\rho_{n=62-2} = -0.133$, $p > 0.1$]. However, SET is strongly associated with NA [$\rho_{n=65-2} = 0.519$, $p < 0.001$] and weakly associated with ASG [$\rho_{n=62-2} = 0.262$, $p = 0.042 < 0.05$]. Finally, ASG is positively related to NA [$\rho_{n=63-2} = 0.421$, $p < 0.001$].

30 participants dropped out during the study (45 %, sic!): 5 during the pre-questionnaire, 18 during the game, and 7 during the post questionnaire. The dropout rate during the pre-questionnaire is negatively associated with the gaming motivation [$\rho_{n=62-2} = -0.281$, $p = 0.026 < 0.05$] and the dropout rate at the post questionnaire is negatively linked with the learning motivation [$\rho_{n=61-2} = -0.254$, $p = 0.048 < 0.05$]. The results section is based on the completed sets and single missing times were deleted on a per-test basis.

4 Results

This section is structured as follows: We first present the determinants for an increased interaction with the game. Second we show the determinants for performance in the game. Third, we explore the components for an increased acceptance. Fourth, we complement the study by reporting verbal feedback of the study's participants.

4.1 Determinants for Increased Game Interaction

The number of changes to the controls in the game varied from 3 to 39 (mean 22.6 ± 10.6, median 22). The single explanatory variable influencing the number of changes is self-efficacy in interacting with technology. People with higher SET did significantly more changes [$\rho_{n=36-2} = 0.367$, $p = 0.028 < 0.05$].

Considering the three levers individually, we find that changes to the incoming goods inspection as well as the procurement [$\rho_{n=36-2} = 0.545$, $p < 0.001$], procurement and own production quality [$\rho_{n=36-2} = 0.560$, $p < 0.001$], and incoming goods inspection and own production quality [$\rho_{n=36-2} = 0.787$, $p < 0.001$] are positively related. This indicates that some people explore the game environment more thoroughly than others. Specifically, we found that people with higher SET experimented with the controls for the incoming goods inspection more often [$\rho_{n=36-2} = 0.465$, $p = 0.004$] and NA also seems to affect this measure [$\rho_{n=36-2} = 0.282$, $p = 0.096 < 0.1$].

4.2 Determinants for Performance

As the *Performance* is not normally distributed [$Z = 0.961$, $p = 0.314 > 0.05$], we refrain from investigating the contributing factors with parametrical methods and report Spearman ρ-coefficients instead. Outcomes are depicted in Table 1. Most independent variables did not relate to the achieved *Performance* in the game. In fact, the only significant relationships are the attitude towards serious games ASG [$\rho_{n=36-2} = -0.327$, $p = 0.051 < 0.1$] and the need for achievement NA [$\rho_{n=36-2} = -0.329$, $p = 0.050 < 0.1$]. Both had a negative influence on performance. Yet, *Performance* is strongly associated with the subjective relative performance [$\rho_{n=36-2} = 0.528$, $p < 0.001$] and the individual's satisfaction with his or her result [$\rho_{=36-2} = 0.672$, $p < 0.001$]. Surprisingly, the number of interactions within the game (see previous section) is also not related to performance [$\rho_{n=36-2} = 0.235$, $p = 0.135 > 0.1$].

Table 1 Spearman's ρ-correlation coefficients for the user factors and the UTAUT2/SGTAM model dimensions (listed if $p < 0.1$, *<0.05, **<0.001)

	EE	PE	HE	FC	SI	PV	TV	REW	LC	TOS	SL	BI
EE	–	0.732^{**}	0.780^{**}	0.447^{**}		0.466^{**}	0.601^{**}	0.693^{**}	0.698^{**}	0.684^{**}	0.434^{*}	0.603^{**}
PE		–	0.671^{**}	0.502^{**}		0.630^{**}	0.516^{**}	0.733^{**}	0.372^{*}	0.834^{**}		0.790^{**}
HE			–	0.497^{**}		0.419^{*}	0.309	0.782^{**}	0.495^{**}	0.720^{**}	0.289	0.619^{**}
FC				–	0.280	0.357^{*}	0.365^{*}	0.498^{**}	0.463^{**}	0.548^{**}		
SI					–							
PV						–	0.717^{**}	0.417^{*}		0.633^{**}	0.317	0.415^{*}
TV							–			0.594^{**}		0.359^{*}
REW								–	0.417^{*}	0.745^{**}		0.595^{**}
LC									–	0.354^{*}	0.432^{**}	
TOS										–		0.747^{**}
SL											–	
SET	0.588^{**}	0.410^{*}	0.574^{**}	0.399^{*}		0.419^{**}	0.472^{**}	0.486^{**}	0.372^{*}	0.534^{**}	0.407^{*}	0.401^{*}
ASG	0.398^{*}	0.477^{**}					0.357^{*}	0.309		0.491^{**}		0.682^{**}
AM	0.319	0.334^{*}	0.349*	0.441*				0.480^{*}		0.470^{**}		0.405^{*}

4.3 Determinants for Acceptance

The overall intention to use the game as a tool for exam preparation is governed by SET [$\rho_{n=36-2} = 0.401$, $p = 0.015 < 0.05$], ASG [$\rho_{n=36-2} = 0.682$, $p < 0.001$], and the NA [$\rho_{n=36-2} = 0.405$, $p = 0.014 < 0.05$].

Performance did neither influence the overall intention to use the game [$\rho_{n=35-2} = -0.155$, $p = 0.373$], nor the individual dimensions from UTAUT2 or SGTAM ($\rho_{max} = 0.224$).

However, there is some evidence that the number of changes to the game environment relates to the usage intention [$\rho_{n=36-2} = 0.293$, $p = 0.088 < 0.1$].

From the perspective of the UTAUT2 and SGTAM models the results indicate a strong positive relationship of most variables on the intention to use the game BI and a strong interconnection between the model's variables (Table 1 summarizes the results). The three strongest influencing factors are Performance Expectancy PE [$\rho_{n = 36-2} = 0.790$], Transfer of Skills TOS [$\rho_{n=36-2} = 0.747$], and Hedonic Motivation HE [$\rho_{n=36-2} = 0.619$]. Within the sample, neither Facilitating Conditions FC, Social Influence SI, Learner Control LC, nor Situated Learning SL significantly influence BI.

As most of the constructs are closely interwoven, the usual procedure would be the application of multiple linear regressions with the user factors and/or the models' factors as independent variables and BI as a dependent variable to untangle this complex net of intercorrelations (cf. [21]). However, due to the small sample, this method yielded only in a single significant model for the user factors and for the models' factors: The model based on the user factors identifies attitude towards serious games ASG as the single predictor for intention to use the game, explaining 61.7 % of the variance in BI ($r^2 = 0.617$, $\beta = 0.792$). From the perspective of the UTAUT2 and SGTAM variables, the model with the single predictor PE explains 59.2 % ($r^2 = 0.592$, $\beta = 0.778$) of the variance in BI. However, we suspect that a larger sample size will reveal multifactorial relationships between user and model factors on BI.

4.4 Qualitative Findings

The participants expressed mostly positive feedback on the overall game. One participant expressed the overall suitability of the game to convey knowledge about production planning and control PPC: "*[…]is really good and useful for understanding the concepts of PPC.*". Another participant suggested the offering of additional games targeted at different learning objectives and postulated higher learning achievements: "*Game was great… need more such games with different concepts. It encourages involvement and understanding real life scenarios*.". Another participant articulated his or her content by stating that the game "[…] *is one of the best way[s] to learn practical industrial problems. This is [a] very nice Game.*"

Criticism was only articulated in regard to the length of the experiment and the administered questionnaires, or to suggest improvements to the game's user interface.

5 Discussion

The presented study provides valuable insights into the acceptance of business simulation games and serious games in general.

First, the overall acceptance of serious games for conveying knowledge of production planning and control and quality management was high, as highlighted by predominantly positive qualitative feedback.

Second, the findings regarding the determinants for attainted performance are counter-intuitive: People with a higher inclination towards serious games and people with higher need for achievement reached—on average—lower scores in the game. We assume that our newly integrated Decision Support System that suggests rather good values causes this effect: Players with the desire to outperform others (e.g., due to their high need for achievement or their high inclination towards games) try to outsmart the game and eventually make mistakes. These are currently difficult to compensate and may then lead to poorer performance compared to those players that solely rely on the suggested values. Surprisingly, we learned that the overall intention to use the game is *not* governed by the attaint performance, but seem to relate to the number of changes to the game environment. Therefore, a follow up study should investigate how performance evolves, depending on the number of rounds played and the number of lessons learned from toying around with the game's controls.

Third, from the perspective of the personality traits and states the study revealed that the trinity of self-efficacy in interacting with technology, need for achievement, and attitude towards serious games are basic constituents of the acceptance of business simulation games, with the latter being the strongest. As these three dimensions are closely interwoven and due to the small sample size, their isolated influence on the usage intention cannot be calculated yet and we suggest a replication with a larger sample. But even now, we observe the strong influence of the attitude towards serious games on the intention to use a serious game (similar to [20]). This seems obvious at first, but unfolds its considerable consequences at the second glance: Serious games will work splendidly, but only for people who enjoy games. People that do not enjoy games might be excluded if teachers exclusively build on game-mediated knowledge dissemination. Hence, we strongly argue for multi-method didactical approaches. Meaning that learning material should be provided in various forms to fit the diverse wants and needs of an increasingly diverse audience.

Fourth, the combination of the UTAUT2 and the SG-TAM model to investigate the acceptance of the QI-Game and business simulation games in general seems to be very promising. Despite the small sample, seven of the eleven dimensions positively relate to the intention to use the game. More importantly, the two strongest predictors *Performance Expectancy* and *Transfer of Skill* originate from the two different models and their influence on BI sustains, even if controlled for the other variable [$r_{PE,BI\backslash TOS} = 0.420$, $p = 0.010 < 0.05$; $r_{TOS,BI\backslash PE} = 0.276$, $p = 0.099 < 0.1$]. This indicates that both models complement each other and may—in combination—contribute more explained variance in BI and later USE than each individual model. Likewise, the newly introduced concept of the *time-value tradeoff* for modeling the invested time for pervading a subject matter also relates to BI and seems to be adequately distinct from the other dimensions of our model. Hence, introducing a time-value tradeoff seems reasonable and a valuable contribution to the methodology of technology acceptance research. Obviously, a follow up with a significantly larger sample should address these two hypotheses.

Fifth, although the strongest predictors could only be picked manually (i.e., without controlling for cross-correlations), we found that *Performance Expectancy* and *Transfer of Skill* were the two dominant predictors that govern the intention to use the game. This directly relates to guidelines for designing future business simulation games for conveying production planning and control, quality management, Systems Thinking and alike: First, these games must be designed and introduced in the way that the individual learners perceive them as directly valuable for their short term benefit, e.g. by positively relating the interaction with the game and the insights gained therefrom to an increased performance in an upcoming exam. Second, by strengthening the belief that the lessons learned in the game will have a long-term benefit in the later work experience and providing adequate examples.

Based on the empirical findings and the analysis of the dimensions from the acceptance models from above, Table 2 presents practical guidelines for designing serious games and to increase their efficacy and likelihood of use.

Table 2 Guidelines for business simulation games derived from the study

Priority	Guideline
1	Provide clearly visible short-term benefits of using the game. E.g., by making clear that the conveyed skills will be beneficial for an upcoming exam. (Based on PE)
2	The player must perceive the presented environment as a simulacrum of the reality. E.g., by portraying realistic production processes. (Based on TOS)
3	Consider learner diversity, especially in regard to different levels of inclination towards games. E.g., by augmenting the game environment with traditional forms of knowledge dissemination. (Based on ASG)
4	Create enjoyable learning environments. E.g., by including potential players in the development to ensure target specific aesthetics and playfulness. (Based on HE)
5	Avoid unnecessary complexity of the user interface and the simulation model, and provide a focused learning experience. E.g., by reducing the perceived effort for mastering the game through guided tutorials, help functions etc. (Based on EE)
6	Provide adequate and immediate feedback on the learning performance. E.g., by linking the learning objectives with the company's profit or by adding motivational incentives (badges, leaderboards, …). (Based on REW)

In summary, the results of the study highlight an increasing importance of Systems Thinking and unfolds principles to design serious games to convey this methodology.

6 Limitations and Outlook

The findings presented above need to be validated with alternative game concepts and different learning objectives to evaluate if the same pictures emerge and the same design guidelines can be concluded. Furthermore, they are based on a small, rather young, and homogeneous sample. Future studies should address the upcoming shift in the demographic structure of many western societies and should investigate the interrelationship of age, the ability to cope with complex socio-technical production systems, and the intention to use business simulation games as a training vehicle.

The study had an unusual high dropout rate. We found hints that this rate is related to a lack of interest in gaming and a lack of perceived learning discipline. A follow up study in a controlled environment with fewer dropouts should investigate the causes for the lack of interest that eventually yields in quitting the study and the game.

The current study did not address if the Systems Thinking abilities were actually positively influenced by the game. We learned from previous studies that the players indeed increased their performance across multiple rounds of the game and that the game positively influenced the attitude towards quality management [24]. Still, the external benefits of this approach in regard to Systems Thinking abilities have not yet been shown. Apart from that we are curious how Systems Thinking abilities might be operationalized in order to formally evaluate the effectiveness.

Acknowledgments We thank all participants of the study and Marco Fuhrmann, Anaïs Habermann, Julian Hildebrandt, and Nicolas Lindstädt for their support. The German Research Foundation (DFG) funded this work within the Cluster of Excellence “Integrative Production Technology for High-Wage Countries” (EXC 128).

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