Gamification of ERP Systems – Exploring Gamification Effects on User Acceptance Constructs

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Abstract

The adoption of game mechanics into serious contexts such as business applications (gamification) is a promising trend to improve the user's participation and engagement with the software in question and on the job. However, this topic is mainly driven by practitioners. A theoretical model for gamification with appropriate empirical validation is missing. In this paper, we introduce a prototype for gamification using SAP ERP as example. Moreover, we have evaluated the concept within a comprehensive user study with 112 participants based on the technology acceptance model (TAM) using partial least squares (PLS) for analysis. Finally, we show that this gamification approach yields significant improvements in latent variables such as enjoyment, flow or perceived ease of use. Moreover, we outline further research requirements in the domain of gamification.

1 Introduction

The process of introducing game mechanics to business software is called *Gamification* and is defined, e.g., as *"[applying] the mechanics of gaming to non-game activities to change people's behavior. When used in a business context, gamification is the process of integrating game dynamics (and new game mechanics) into a website, business service, online community, or marketing campaign in order to drive participation and engagement"* [2].

According to [13] today's gamers can be characterized as follows:

- Sixty-five percent of American households play computer or video games.
- The average game player is 35 years old and has been playing games for 13 years.
- The average age of the most frequent game purchaser is 40 years.
- Forty percent of all game players are women.

Additionally, more than five million people in the USA play games for 40 hours a week [12] and gamers have collectively spent 5.93 million years playing World of Warcraft [17].

Obviously, the group of people who are working and intensively playing games is relatively large. This leads to the question, if enterprise software can provide the same motivation for people as games do? More recently, researchers have begun to discuss this so called gamification of non-gaming contexts on conference workshops (e.g., [11]). The argumentation is further supported by, e.g., [30] stating that: *"In the past decade, virtual worlds have demonstrated the potential to be the next generation of interface for entertainment, interaction, content and e-commerce. [...] virtual worlds [...] become a huge business [...]"*.

Thus, the intention of this and future research is to develop and evaluate a gamification approach for one pervasive business application, e.g., Enterprise Resource Planning (ERP). The idea is to compare two different ERP concepts with each other. Hereby, the first approach is the traditional, hierarchical ordered and form based graphical user interface of SAP ERP (SAPGUI). The second concept is our gamification prototype in the style of real-time strategy games, such as SimCity, Anno or Age of Empires, augmented with game concepts, such as rewards. The general goal of this research is to find out, whether the gamification approach is better suited regarding ease of use, usefulness, efficiency, productivity, motivation, or enjoyment and thus may enhance usage intentions. Based on a theoretical model derived out of a broad literature review we have conducted a study to evaluate the user's acceptance toward both technological visualization approaches.

Hereby, our findings give answers to the following research questions:

RQ1: Which theoretical framework is suitable to explain usage intentions of applications with game mechanics?

RQ2: Does gamification yield improvements in latent variables of software usage, e.g., enjoyment, perceived ease of use, or perceived usefulness?

The rest of the paper is structured as follows. First, the research model is presented by outlining assumptions and limitations. Second, the prototype is described shortly. Third, the user study is characterized and evaluation results are presented. Fourth, a short discussion summarizes our findings. The paper closes with an outlook on further research.

2 Research Model and Hypotheses

The research model for this paper is based on the technology acceptance model (TAM) [6],[7], the DeLone & McLean information system success model [9] and flow theory [5].

The model itself was derived under the following pragmatic limitations. First, the entire study must not take more than half an hour for an experienced SAP user. Thus, the time to work with the game prototype was limited to fifteen minutes. More importantly, answering the questionnaire must not take more than ten minutes. Second, the participants are mainly from academic institutions, e.g., students, professors or researchers, most of them with an SAP ERP background. Third, the prototype cannot cover the entire functionality of SAPGUI, thus, it is possible that participants underestimate the effect of usefulness. Fourth, the prototype decreases much of the complexity of SAPGUI, which again can lead to bias in the evaluation results.

Given these limitations, only an *ex ante* perspective to measure usage intentions seemed to be appropriate. Hence, TAM was used as the base model [28].This mainly results from the observation, that the prototype in question is compared with a generally available product (SAPGUI). In TAM the behavioral intention (BI) to use a particular software is determined by its perceived usefulness (PU) and its perceived ease of use (PEOU).

Besides the limitations illustrated above, further assumptions were taken into account while deriving the model. First, functionality was assumed to be identical between both solutions, thus, no further antecedents of *perceived usefulness* are considered in the final model. Second, due to the large amount of possible antecedents of *PEOU* and *flow* (e.g., [14]), only first-level antecedents were considered. Third, the impact of both visualizations on the user is measured on the individual's level according to the levels introduced in the D&M IS Success Model [8].

Since the first version of the model resulted in far too many constructs and questionnaire items (162 items) respectively, a more parsimonious model had to be created using additional assumptions. First, all *system quality* constructs that act as antecedents to PEOU from the IS Success model were omitted because the prototype could not fulfill non-functional requirements such as *reliability*, *flexibility* or *accessibility* [28]. Second, the remaining constructs from the TAM domain were classified into two classes: user- and user-system dependent.

Within the first class only constructs are subsumed that represent general information individuals rely on regarding software that has nothing to do with the software system itself. The latter class covers constructs that represent the direct experience with the system. These variables are formed when "additional information becomes available" [23]. In order to omit further constructs, only the user-system dependent constructs, that is, enjoyment, content/interface, telepresence and interactivity were retained. This led to the final research model depicted in Figure 1. For a more detailed description of how the final model was constructed see [14]. Overall, a set of twenty hypotheses has been declared as presented in Table 1. In this table, *V1* represents SAPGUI and *V2* the game prototype. The a-hypotheses were derived out of an extensive literature review and are to be tested for each system separately while the b-hypotheses are used to test whether the constructs in question are significantly improved by *V2* in order to answer *RQ2*.

The measurement model of the structural equation model (SEM) is derived, in turn, out of prior work. First, all items on *interactivity* are taken from, e.g., [4][14][18], questions on *interface* are from, e.g., [4][14][27]. Items for *telepresence* are derived from, e.g., [18] and *flow* from, e.g., [18][14]. *Enjoyment* items are from [23][24]. Question of *PU*, *PEOU* and *BI* are used from the TAM model authors, that is, e.g., [6][7][23]. All items are measured on a 5-point Likert scale.

The German translation of the questionnaire has been checked in a previous peer-review with five potential respondents. After this review, wording and translation changes were included into the questionnaire (the questionnaire can be requested from the first author).

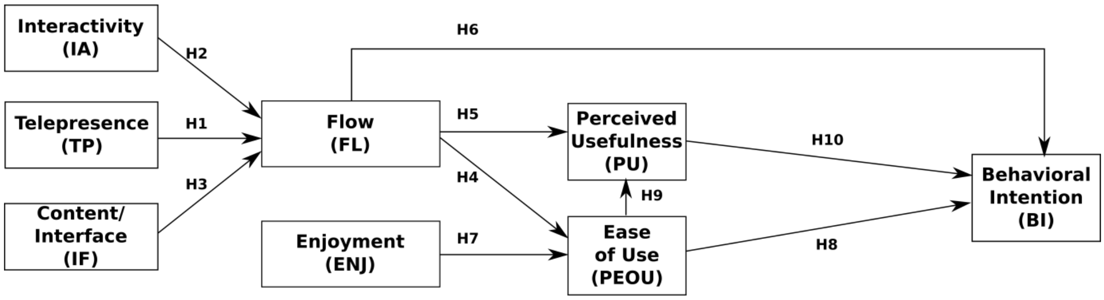

Figure 1: The final research model

Number	Hypothesis
H1a	Telepresence has a positive effect on flow. (e.g., [18])
H1b	Telepresence is higher in V2 than in V1.
H2a	Speed of interaction has a positive effect on flow. (e.g., [18])
H2b	No difference in speed of interaction between V1 and V2 exists.
H3a	The perceived quality of the interface has a positive effect on flow experience. (e.g., [4])
H3b	The perceived quality of the interface in V2 is greater than in V1.
H4a	Flow has a positive effect on perceived ease of use. (e.g., [1])
H4b	Iff flow is significantly higher in V2 than in V1 AND hypothesis H4a is true, then PEOU is higher in V2 than in V1.
H5a	Flow has a positive effect on perceived usefulness. (e.g., [1])
H5b	Iff flow is significantly higher in V2 than in V1 AND hypothesis H5a is true, then PU is higher in V2 than in V1.
H6a	Flow has a positive effect on behavioral intention. (e.g., [16])
H6b	Iff flow is significantly higher in V2 than in V1 AND hypothesis H6a is true, then behavioral intention to use V2 is higher than for V1.
H7a	Perceived enjoyment has a positive effect on PEOU. (e.g., [23])
H7b	Perceived enjoyment is higher in V2 than in V1.
H8a	PEOU has a positive effect on BI. (e.g. [16] [24])
H8b	Iff PEOU is significantly higher in V2 than in V1 AND hypothesis H8a is true, then BI is higher in V2 than in V1.
H9a	PEOU has a positive effect on PU. (e.g., [16],[24])
H9b	Iff PEOU is significantly higher in V2 than in V1 AND hypothesis H9a is true, then PU is higher in V2 than in V1.
H10a	PU has a positive effect on BI. (e.g., [16],[24])
H10b	Iff PU is significantly higher in V2 than in V1 AND hypothesis H10a is true, then BI is higher in V2 than in V1.

Table 1: Hypotheses for structural equation model

3 Prototype

Within the prototype a manufacturing scenario is covered consisting of material management (MM), sales and distribution (SD) and production planning (PP). From these ERP modules only a small set of business transactions is implemented ultimately, e.g., “create sales order (Transaction: VA01)“ or “display purchase order (Transaction: ME23N)“. Moreover, only the most important parameters of these transactions are realized within the prototype.

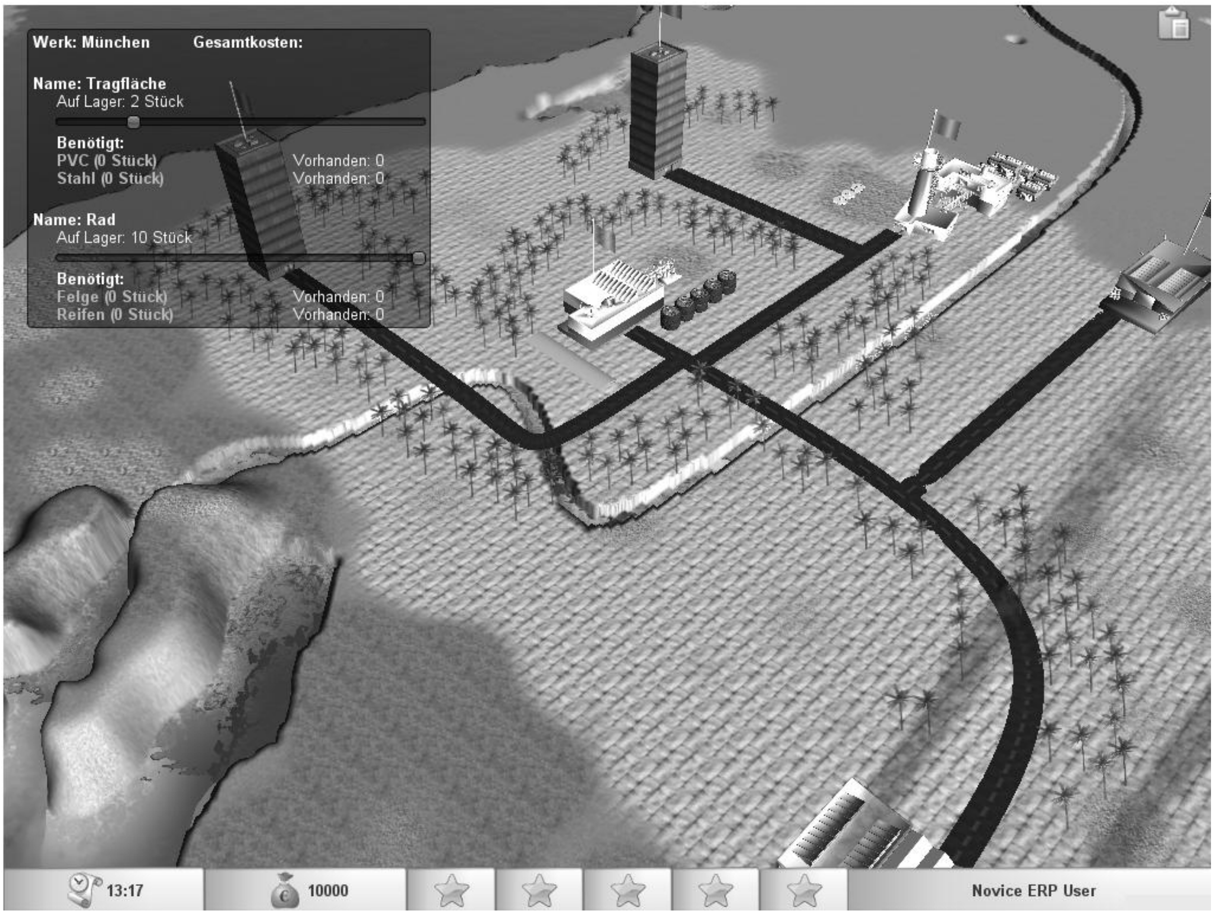

Figure 2: Game prototype

The entire scene remains static whereas the user's enterprise consists of two production plants, two suppliers and two customers. The user has time for thirteen and a half minutes to fulfill all purchase, sales and production missions. Additionally, the user has a budget of $10000 by default for executing the tasks. Given these assumptions, the user has to solve six different missions which increase in difficulty.

The game prototype uses the following five game mechanics in accordance with [2] & [19]. First, a virtual reality that provides graphical visualization of processes and data (see Figure 2). Second, challenges [2] in the form of clear goals and clear rules. Third, levels realized as rank upleveling. Fourth, rewards as stars for each mission which has been completed successfully. Fifth, immediate cash feedback that acts as another reward mechanism. As an interesting effect, participants start to play the game over and over again, until all stars were reached. When all stars were already reached the users restarted the game over and over again in order to get the most cash in the game. A process called mastery by positive psychologists [17]. The prototype was realized using Unity 3D [22] and Visual Studio 2010 as authoring tools.

4 Empirical Evaluation

The following section characterizes the user study and presents the research results.

4.1 General Setup

The user study lasted two months from 15.05.2011 until 15.07.2011. Within this time frame 112 responses were collected.

Participants were mainly academic personnel, but also novice ERP users, SAP employees and long-term SAP users were interviewed. The questionnaire was realized via *online-Fragebogen* [21] and was administered directly after using the game prototype and SAPGUI.

The following settings were used in SmartPLS [20] for evaluation. First, the PLS algorithm was applied with path weighting scheme, 1000 maximal iterations and 1^{-5} as quit criterion. The output of this procedure are path weights, quality measures, such as average variance extracted (AVE), Cronbach's alpha (CR), R^2, Stone-Geisser's Q^2, inner/outer loadings, item cross loadings and construct correlations. Second, bootstrapping was applied to retrieve significance values by running the algorithm with 112 cases and 1000 randomly selected subsamples. The output of this procedure are t-values which are comparable against a student's t-distribution on a 5%(one-side)/10%(two-side) level. The critical value of the t-distribution with 112 degrees of freedom on one side is 1.659 which must be exceeded by the t-value of the respective path weight in order to be significant. Third, a blindfolding procedure was applied to determine Stone-Geisser's Q^2 measures with an omission distance of seven.

4.2 Descriptive Statistics

In order to characterize the sample we provide the exogenous variables *age (AGE)*, *SAP experience (SAPEXP)*, *Game experience (GEXP)* and *Count of rewards (COR)*. The average respondent in the sample is 25.45 years old, has slightly more experience in strategy games (3.018) than in SAP ERP (2.786) and achieved 3.786 stars in the game prototype.

There are also significant correlations (Pearson's correlation: ρ_{ik}) between these variables leading to the following observations. First, the older the participant the lower is the experience with strategy games, such as Anno ($\rho_{ik} = -0.2015$). Second, the older the participant is the higher is the experience with SAP ($\rho_{ik} = 0.256$). Third, men have much higher experience in strategy games than women ($\rho_{ik} = 0.422$). Fourth, the higher the experience in games the more stars does one achieve in the prototype ($\rho_{ik} = 0.4465$). Consequently, a positive correlation between gender and rewards exists, that is, men achieve more stars than women ($\rho_{ik} = 0.297$).

4.3 Structural Equation Model for SAPGUI

After the estimation of the structural equation model (SEM) for SAPGUI, each construct has exceeded the acceptable thresholds of 0.5 for average variance extracted (AVE) and 0.6 for Cronbach's alpha (CA) and composite reliability (CR) except *interactivity* where AVE is slightly below 0.5 and CA far too small (0.231). Obviously, this variable was not measured appropriately. As one can see from the SEM in Figure 3, *interactivity* has no significant impact and is, thus, a candidate for exclusion from the model. Furthermore, discriminant validity between the constructs is ensured because the square root of the AVE value is substantially higher than each inter-construct correlation. Additionally, each item loads on its intended factor within a confirmatory factor analysis (CFA).

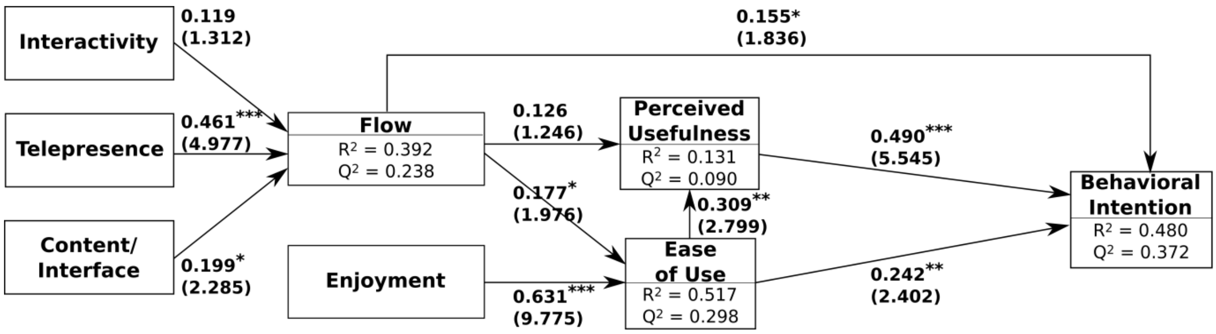

Figure 3: Estimated SEM for SAPGUI[1]

Moreover, *FL*, *PEOU* and *BI* are showing an acceptable fit value. However, the R^2 of *PU* is rather low. Nevertheless, this is acceptable for further considerations since *PU* is only determined by *FL* effects directly which is, on the one hand, usually a weak predictor and, on the other hand, other important antecedents of *PU*, such as image or job relevance, were omitted from the research model. More importantly, the prediction quality is above zero and over 20% better than simple mean predictions. Predicting *BI* shows even an improvement of 37,2%. Hence, the predictive power is acceptable according to the literature.

The relationships *IA-FL* and *FL-PU* are not significantly different from zero, thus, they are omitted from further considerations. Consequently, also hypotheses **H2a** and **H5a** have to be rejected. Moreover, *telepresence* is the strongest predictor of *FL* in SAPGUI (0.461) besides interface which explains 19.9% of flow's variance. Thus, hypotheses **H1a** and **H3a** are confirmed within this study. Furthermore, *enjoyment* is the strongest antecedent of *PEOU* (63.1%) and, therefore, confirms hypothesis **H7a**. Also flow has a positive impact on PEOU (17.7%) whereby **H4a** can be confirmed. In accordance with the TAM literature, *PU* explains around 50% of the variance in *BI* and *PEOU* explains around 25% which gives support to **H8a** and **H10a**. Additionally, *PEOU* positively impacts *PU* (0.309) too, confirming hypothesis **H9a**. This is an important observation, because under the assumption that the prototype improves *PEOU* only, the improvement must be very strong to improve *BI* finally. Besides *PU* and *PEOU*, also *FL* shows a small but significant direct effect on *BI* (15.5%). Therefore, also **H6a** is confirmed.

4.4 Structural Equation Model for Game Prototype

Figure 4 illustrates the SEM for the game prototype. All quality criteria are, again, above the defined thresholds of 0.5 for AVE and 0.6 for CR and CA respectively. However, *IA* as latent variable is, in turn, not reliably measured by its items. Nevertheless, *IA* is has no significant impact on *flow* either and is, finally, not considered any further.

Moreover, the square root value of AVE was substantially higher for each individual construct than the correlation with any other construct in the model except for *interface* and *PEOU*. Obviously, the items are very similar and we, thus, argue that in the game prototype both constructs are influencing each other mutually. However, the rest of the constructs are accounting for good discriminant validity.

[1] Values without brackets are path weights γ_i; Values in brackets are t-values from bootstrapping; Significance levels: < 0.1% (***), <1% (**), <5% (*), <10% (‘).

Furthermore, all items are loading on their intended factors, except *IA*. Only one item loads on the *IA* component leading to a one item scale. However, as mentioned before, *IA* will be excluded from the model ultimately because the effect on *FL* is not significant in the structural equation model.

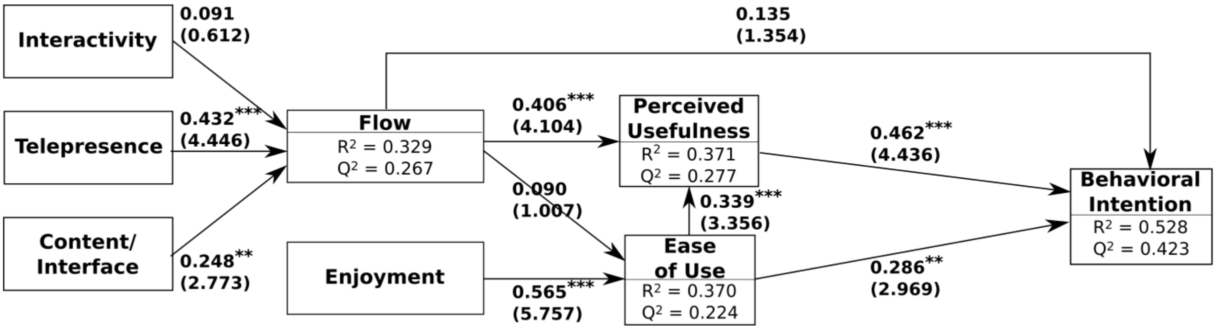

Figure 4: Estimated SEM for Game Prototype

As for SAPGUI, R^2 values are above moderate and strong explanatory power. Moreover, the predictive power of the model can be considered as very good because, e.g., BI is 42.3% better predicted than with mean prediction.

One can see that the relationships *IA-FL*, *FL-PEOU* and *FL-BI* are not significant in the model and are, thus, omitted from further considerations. Hence, the hypotheses **H2a**, **H4a** and **H6a** are rejected. As well as for SAPGUI, *TP* is the strongest predictor of *FL* (0.432) besides IF with 24.8%. Thus, hypotheses **H1a** and **H3a** are confirmed. Furthermore, ENJ is the strongest predictor of *PEOU* which supports hypothesis **H7a**. Additionally, *PU* (0.462) nearly doubles the effect of *PEOU* (0.286) on *BI*. Therefore, also hypotheses **H8a** and **H10a** are true. Finally, *PEOU* explains 33.9% of PU's variance because of *PEOU*'s instrumental value, thus, supporting **H9a**. It is interesting to note, that *FL* has a strong impact on *PU* (0.408) leading to a confirmation of **H5a** and a substantially higher R^2 of *PU*.

4.5 Analysis of Variance

Ultimately, the latent variables should be compared in order to show if the game prototype yields improvements. Therefore, Table 2 presents means and standard deviations of the final factor scores. In addition the p-value of the Jarque-Bera test is given to show that not all variables are normally distributed. Although the assumption of normality is rejected, ANOVA provides a robust test decision when compared with the outcome of the Wilcoxon-Whitney-Mann test (U-test) which has no distributional assumptions. Both tests are rejecting the null-hypothesis of equal means.

Factor	Mean	S.D.	Jarque-Bera (p-value)	ANOVA (p-value)	U-Test (p-value)
IASAPGUI	2.990	0.754	0.518	0.395	0.378
IAGame	3.091	0.989	0.327		
IFSAPGUI	3.089	0.878	0.158	$1.743^{-09\ (***)}$	$1.831^{-10\ (***)}$
IFGame	3.812	0.846	$1.820^{-08\ (***)}$		
TPSAPGUI	1.946	0.800	$0.00370^{(**)}$	$3.351^{-06\ (***)}$	$7.815^{-06\ (***)}$
TPGame	2.525	1.0003	$0.0846^{(.)}$		
FLSAPGUI	1.924	0.972	$0.00158^{(**)}$	$1.968^{-05\ (***)}$	$3.207^{-05\ (***)}$
FLGame	2.508	1.030	$0.0503^{(.)}$		
ENJSAPGUI	2.533	0.960	0.124	$2.2^{-16\ (***)}$	$2.2^{-16\ (***)}$
ENJGame	3.886	0.850	$1.381^{-08\ (***)}$		
PEOUSAPGUI	2.807	0.828	0.832	$2.2^{-16\ (***)}$	$4.441^{-16\ (***)}$
PEOUGame	3.821	0.839	$0.000748^{(***)}$		
PUSAPGUI	3.303	0.899	$0.00661^{(**)}$	0.435	0.8299
PUGame	3.203	0.995	$0.0373^{(*)}$		
BISAPGUI	3.408	1.108	$0.0366^{(*)}$	0.2731	0.2030
BIGame	3.574	1.149	$0.00430^{(**)}$		

Table 2: Analysis of variance of factor scores

Thus, the following conclusions can be derived. Interactivity increases by 0.101 which is not significant according to the mean test. Thus, **H2b** is confirmed. Again, results for interactivity have to be interpreted cautiously as this construct was not measured properly. Interface (0.723), telepresence (0.579), flow (0.584), enjoyment (1.353), perceived ease of use (1.014) are significantly increased leading to a confirmation of **H1b**, **H3b**, **H4b** and **H7b**. Although antecedents of PU are improved in the game prototype, PU itself even decreases leading to a rejection of **H5b** & **H9b**. Furthermore, BI is improved on average but the difference is not significant according to ANOVA, probably because flow has no significant impact on BI in the prototype model. Thus, hypotheses **H6b** & **H8b** can be partially confirmed only and we argue that further research is necessary. Ultimately, **H10b** is confirmed because neither **H5b** nor **H9b** were true in this study.

5 Discussion

In the following paragraphs improvement is always seen from the prototype's perspective. Hence, telepresence is improved by 29.75%, interface by 23.4%, flow by 30.353%, enjoyment by 53.414%, and perceived ease of use by 36.123%. However, perceived usefulness decreases by 3.03%. The intention to use ERP software is increased by 12.12%. When comparing the path weights γ_i, one can see that the differences are very small in most cases. However, there is a substantial increase on the FL-PU relationship (68.966%) and decrease on the FL-PEOU one (-96.66%). Furthermore, the ENJ-PEOU relationship is also decreased by 11.681%. This is an important observation, since it was shown in Section 4.5 that all constructs, that is, flow, enjoyment and perceived ease of use, are improved significantly on average but all paths leading to PEOU are of less explanatory power in the prototype's model. In other words, the relative increase in PEOU is not only determined by the measured variables. Therefore, we argue, that PEOU is determined by further antecedents that lead to higher PEOU in the game prototype and were not measured in this study. Additionally, one can conclude that these variables should only have a small impact on PEOU in SAPGUI. Thus, future research needs to identify additional possible antecedents of PEOU when TAM-based models are applied to applications with game mechanics.

On the other side, all path weights leading to PU are improved (8.85% for PEOU-PU and 68.966% for FL-PU) in the prototype's model. In addition, also the antecedents of PU are increased as shown above. However, as illustrated in Section 4.5, PU decreases slightly on the construct level when both solutions are compared with each other. Hence, there exists an obvious contradiction. Therefore, we argue, that other factors which were not measured in this study possibly have a strong negative impact on PU in the prototype's model.

Besides the quantitative feedback from the questionnaire, individual qualitative feedback was collected. Especially, participants were asked why they have diminished or augmented PU and PEOU respectively. The following list gives an overview of qualitative feedback why perceived usefulness was reduced. First, participants cannot imagine that an entire ERP solution or parts of it are realized with such a gamification approach. Second, participants did not understand how gamification should improve their performance because the evaluation period was too short, the given scenario not appropriate/understandable or participants were not fully concentrated on their tasks due to the time limitations of the study. Third, participants, especially from the areas of finance and accounting, were afraid of the three dimensional virtual reality because they would expect a spreadsheet format as graphical frontend. It is interesting to denote that these reasons can be derived mainly out of the assumptions and limitations of the study. It seems obvious, that a longer study, based on a sample closer to the target group with an improved prototype in a real business context should circumvent the negative points outlined above. Moreover, a parallel with antecedents of PU from the TAM3 model can be drawn. In this model, antecedents of perceived usefulness are *subjective norm*, *image*, *job relevance*, *output quality* and *result demonstrability* [24]. We argue, that *job relevance* which is defined as "the degree to which an individual believes that the target system is applicable to his or her job" [25] and *output quality* which is defined as "the degree to which an individual believes that the system performs his or her job tasks well" [25] might have the strongest negative impact on PU within the prototype's model according to the qualitative feedback given above. Of course, other factors that are not validated in TAM3 or any other model may have a negative influence as well.

Regarding the explanatory gap in PEOU, TAM3 can be used again to propose further research questions. Perceived ease of use is not only determined by enjoyment or flow as system dependent antecedents but also by user dependent constructs, such as *computer self-efficacy*, *perception of external control*, *computer anxiety* or *computer playfulness* [24]. We argue, that especially factors like computer self-efficacy or computer playfulness which are intrinsic motivators for using any kind of new system are very likely high in our sample since the average age of the participants is relatively low (25.45).

Overall, we showed that the presented model provides a good start to explain usage intentions, but it needs enhancements as argued above when applied to applications with game mechanics (RQ1). Due to the exploratory nature of our research and the application of the proposed model in order to identify differences while comparing two systems this drawback does not pose threats to the validity of our answers to RQ2. We clearly showed that all of the constructs improved through gamification, most of them significantly. Therefore our study strongly encourages further investigation of ERP gamification and its outcomes.

6 Outlook

In this paper we have presented a theoretical model for the evaluation of our ERP gamification prototype. We have shown that gamification objectively yields improvements in factors, such as software enjoyment, flow experience or perceived ease of use. However, the behavioral intention to use the prototype has not increased significantly because perceived usefulness decreases due to the presented limitations of the user study. Hence, we argue that the same effects should be estimated with an improved prototype evaluated in a larger work setting. Moreover, we propose to investigate the effects within a larger theoretical framework, such as the job-demands resource model (e.g., [2],[10]) because flow and enjoyment which are substantially increased by gamification have a strong positive effect on work engagement. Hence, we hypothesize that gamification can increase quality on the job and improve even organizational outcomes, such as job performance or organizational commitment.

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