Gamified Hands-on-Training in Business Information Systems: An Educational Design Experiment

Anke Schüll[a], Laura Brocksieper and Julian Rössel
Department of Business Information Systems, University of Siegen, Kohlbettstr. 15, Siegen, Germany

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Abstract: The Covid-19-pandemic confronted lecturers worldwide with the sudden necessity to develop concepts suitable for distance education. Students' motivation became a crucial aspect of prolonged e-learning situations. This paper reports on an educational design experiment to change a hands-on-training on SAP ERP-Systems into a gamified self-paced e-learning environment. This training accompanies a lecture on Business Information Systems for first-semester students. Allowing mistakes to happen kept the attention high and made achievements within the learning environment more rewarding. An anonymous online survey confirmed the relevance of self-paced learning for learning efficiency. Even though a positive impact of "mistakes" on learning efficiency was not confirmed, comments and statements of the participants pointed towards an effect on learning, worth further research. We contribute to the body of knowledge by providing lessons learned on gamified self-paced e-learning within university courses. It could be verified that business process-related hands-on-training within an ERP-System could be implemented in a gamified self-paced e-learning environment without compromises regarding scope or scale of the content.

1 INTRODUCTION

The Covid-19-pandemic changed the working and the learning situation globally. Work motivation and behavior, health, well-being, job and career attitude changed (Spurk and Straub, 2020). Schools and universities closed. The impact of social isolation on students and their attitude towards using learning-management systems became a topic of research (Raza et al., 2021). Lecturers worldwide were confronted with the sudden necessity to develop concepts suitable for distance learning. Keeping students motivated became a crucial aspect of prolonged e-learning.

Gamification describes the use of playful elements in non-game activities, e.g. to increase engagement within an otherwise less enjoyable context (Bakker and Demerouti, 2007). Elements of gamification are e.g. rewards, badges, and high scores (Turk and Goren, 2017). Using gamification to support the learning process can strengthen students' perseverance and resilience (Aguilera and Martínez, 2017), arouse their interest, and increase their motivation.

More fun, a more intense flow experience (Herzig et al., 2012) and better learning outcomes than with conventional training methods (Alcivar and Abad, 2016) were reported on gamified ERP-system training. In a comparative study, gamification was found to increase motivation and interest, even though it was perceived to be more time-consuming (Barata et al., 2013).

This let to an Educational Design Experiment: the transformation of the hands-on-training within the SAP enterprise resource planning-system (ERP-System) towards a gamified self-paced e-learning environment. The training accompanies a lecture on Business Information Systems (BIS) for first semester students of the University of Siegen. Most of these students had no preliminary knowledge of the topic.

This paper contributes to the body of knowledge by providing lessons learned on gamified self-paced e-learning within university courses. Taking wrong turns, making mistakes and failure are part of the challenge that make achievements more rewarding. Within e-learning environments, learning from mistakes is a still underdeveloped field of research.

[a] https://orcid.org/0000-0001-9423-3769

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The educational design experiment presented in this paper reports on the transformation of a hands-on-training towards an e-learning environment with elements of *gamification*, *self-paced learning* and *learning from mistakes*.

2 LITERATURE REVIEW AND FORMULATION OF HYPOTHESES

Educational design research is an experimental approach on the iterative development of solutions to practical and complex educational problems (McKenney and Reeves 2021, 2014). Self-regulated learning and a constructive handling of mistakes became two requirements that shaped the design of the e-learning environment. Design decisions were made to give the students a maximum of control over their learning process, and to allow mistakes to happen as part of the learning progress.

The implementation allows an evaluation of student's perception of these concepts build on personal experience. To assess students' perception, two independent variables are evaluated, whose impact is assumed to influence learning efficiency: self-paced learning and learning from mistakes.

Within a university, students have to learn autonomously in a self-regulated manner (Anurugwo 2020). Self-regulated learning platforms encourage students to actively get involved in the learning process (Anthonysamy et al., 2020) and allow them to learn and understand the content at their individual speed (Turk and Goren, 2017; Anurugwo, 2020). Self-paced learning can improve students' academic achievements and prepares for life-long-learning (Bautista, 2015). Self-paced learning environments can support students in building cognitive and metacognitive knowledge based on hands-on experiences (Bautista, 2015). Self-paced learning tools support learning effectively (Marshman et al., 2020). Therefore, we postulate:

H1: Self-paced Learning Has a Positive Effect on Learning Efficiency.

Hands-on-training allow students to get actively involved. The possibility to make mistakes during the learning process in combination with feedback, promotes the learning success (Tulis et al., 2016). Learning speed, understanding of the underlying concepts and a transfer to new tasks were improved by a constructive handling of mistakes during the learning process. Similar findings were confirmed in a study by Metcalfe (2017). Confronted with critical situations, those subjects who were exposed to errors and mistakes during their learning process reacted better and could adapt more flexibly than those who were spared the confrontation with errors during the learning process: learning perseverance improves. This is consistent with literature on resilience, a trait that is acquired at least in part through learning (Coutu, 2002). Thus, the second hypothesis results in:

H2: Mistakes Have a Positive Impact on Learning Efficiency.

During this experiment, student teachers supported two groups of up to 30 students each. They took notice of student reactions and observed their progress within the ERP-System. To avoid influencing the behaviour of the participating students, all interactions remained undocumented. To assess the perception of the requirements implementation, an anonymous online survey was included into the e-learning environment at the end.

3 EDUCATIONAL DESIGN EXPERIMENT

Educational design experiments can be used to solve a problem (here: taking up the sudden challenge of prolonged and distant e-learning), to put knowledge to innovative use (here: longterm experiences with hands-on ERP-training and research literature led to a new concept for gamified self-paced learning), and/or to increase robustness and systematic nature of design practices (McKenney and Reeves, 2021).

Herzig et al., (2012) and Alcivar and Abad (2016) reported on the implementation of hands-on ERP-training within an e-learning environment. In this educational design experiment, aspects of gamifications are included. The e-learning environment covers the full content of the course in a playful way. No compromises were made regarding scope or scale of the content. A game board visualizes the context (Figure 1). The spokes in the background of the layout are related to the topic: the production of bicycles. Even though the learning management system Moodle is available at our university, this game board was placed outside Moodle on a website, an environment unrelated to learning. To raise students' interest was the intentions and once they started the learning process to keep them motivated all the way through. A variety of media was mixed to avoid monotony. Suiting to the topic, the shooting of some videos was located in the landscape on local bicycle routes. Associations with leisure activities were expected to bring more ease into the learning process.

Learning objects of the hands-on-training in the SAP ERP-system are logistical processes, material and information flows. Business processes (procurement, manufacturing, stock management, sales and support) and the supportive use of ERP-Systems are at the core of this course. All student learners are responsible for their own materials. A multi-layered bill-of-material (BOM) is used, containing raw materials, semi-finished and finished products (here: a bicycle). The processes are integrated and complexity increases with the progress: sales orders trigger manufacturing and manufacturing can only be executed, if raw materials are in stock. If not, procurement of the raw materials is required. The interconnectedness between the many processes leads to increased complexity.

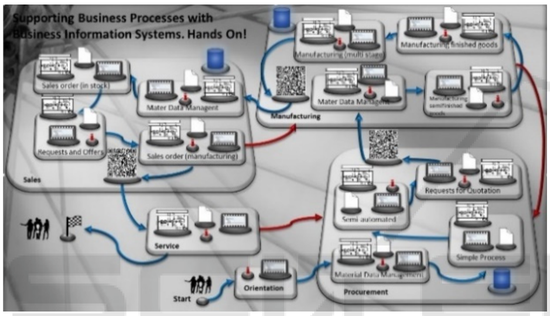

Figure 1: Layout.

The elements of the game board are interactive. Explanations of the contents of the case studies and screencasts on the functionality of the ERP-system are part of the learning environment. The pace is self-regulated. The graphic elements of the game design are largely self-explanatory to enable intuitive use:

- Each plate corresponds to a mission (a scenario or a subprocess),
- Arrows guide through the roadmap, marked in different colors. Steps back to preceding sub-processes or scenarios are marked in red.
- Each scenario is described by three elements:
  - A process diagram (BPMN 2.0). Explanatory videos on the process are embedded within these diagrams.
  - Data sheets.
  - Screencasts.
- QR codes link to mini-quizzes.
- Flashing blue lights direct to a trouble-shooting file that empowers students to "self-help", if mistakes occur.
- Feedback option/evaluation.

Goals and process steps are explained at the beginning of each scenario via process diagrams according to BPMN 2.0 (Business Process Model and Notation). Videos add explanations to the process diagrams. Scenarios are the "missions" to be completed within the ERP-system. The pace is controlled by the students themselves. The completion of a mission is rewarded with a badge in Moodle. There is no best list, but how many other students have achieved this badge, is visible. Badges can have a positive effect on user activities (Hamari, 2017). Badges show the achievements of the participating students and trigger competitive behavior.

Each scenario is a mission. The repair of a bicycle previously delivered to the customer, is one process instance students have to deal with. The repair of this bicycle involves the replacement of a defective gearshift, one of the components according to the BOM of this bike. If the activities were carried out correctly within the ERP-system, this gearshift should not be available in the warehouse: students need to start another instance of the procurement process, before the repair of the bicycle can be carried out and the service notification closed. As a service to the customer, costs are settled via an internal cost center.

Mistakes can happen at any point in the scenarios, but are most frequent in master data management. Master data management and the importance of data quality are important aspects of the scenarios. In preparation for real-life-environments, flaws in data quality should have an impact. Preventing students' mistakes would be counterproductive to the learning outcome. They were allowed to happen and if they do, they have an impact on the process.

Three aspects are important for effective "learning from mistakes" (Metcalfe, 2017): mistakes were made by the student learners themselves, they receive corrective feedback and this corrective feedback leads to a correct answer, a correction of the mistake or problem solving. Corrective feedback should remind learners of the context in which the mistake was made (Metcalfe, 2017) and to assist in uncovering the cause, fixing it and reflecting on it. Reflection and the search for explanations improve the understanding. Problem-solving paths become visible, which can empower learners to correct errors themselves. As mistakes can be taken emotionally (Kartika, 2018), corrective feedback needs to be careful and constructive.

The flickering blue light links to a trouble-shooting file with typical error messages and explanations of their causes (corrective feedback). This empowers the student learners to cope with mistakes without assistance. The sense of control thus remains, even when mistakes occur. As a second escalation level, students are assisted by tutors who provide corrective feedback.

4 QUANTITATIVE ANALYSIS

The participants of the hands-on-training on integrated business processes in the SAP ERP-System were invited to participate in an online survey. There were no incentives, the survey was anonymous, participation voluntary. The questionnaire followed the research model, using a five-point Likert scale to measure the items and some free-text fields for students' comments.

231 students passed the course in the autumn semester 2020/21, 72 (31%) filled out the questionnaire. 25 data sets were incomplete and dismissed from further analysis. Even though with 47 remaining data sets, the sample size is poor (Comrey and Lee, 2016), the data sets covered 20% of the participants and their analysis was expected to provide valuable insights.

SmartPLS version 3.3.3 (Ringle et al., 2015) was used to analyse the data. SmartPLS is a software for SEM-PLS (Henseler, 2017) frequently used in literature on information systems (e.g. in Kijsanayotin et al. 2009, Celik 2016, Gunawan 2018, Raza et al. 2021). The partial least square structural equation modeling (PLS-SEM) was performed in two stages: Stage one involved the evaluation of the measurement model (reliability and validity of constructs). The second stage involved the evaluation of the structural model (inner loadings). Within the first stage the validity of the items was examined (Table 1).

Table 1: Mean and Standard deviation (SD).

Item	Mean	SD
LE1: I feel like I have learned more about the ERP system.	3.6	1.23
LE2: My understanding of business processes has improved.	3.51	1.16
LE3: I learn about business application systems more effectively than through lectures.	3.7	1.08
M1: Mistakes helped me to understand the contexts better.	3.49	1.28
M2: Learning from mistakes can promote a positive attitude in the process.	3.66	1.27
SL1: I like being able to determine the learning speed by myself.	3.94	1.45
SL2: I like being able to learn the material at any time.	4.11	1.51
SL3: I like being able to learn anywhere.	3.96	1.47
SL4: Time passes quickly in this environment.	3.87	1.17
SL5: Noise doesn't distract me when I'm studying.	3.47	1.47
SL6: It makes me feel good.	3.72	1.04

Cronbach's Alpha was calculated to assess the scale's reliability (Tabachnick and Fidell 2014), those underneath 0.55 were dismissed from further analysis. After validity of the items was confirmed, reliability of the constructs was assessed.

Table 2: Reliability (CR = Composite Reliability, AVE = Average Variance Extracted).

	Cronbach's Alpha	CR	AVE
LE	0.880	0.879	0.709
M	0.816	0.821	0.697
SL	0.942	0.941	0.728

Composite Reliability (CR) is higher than 0.7 for all constructs (Table 2). Cronbach's Alpha was calculated to assess the scale's reliability (Tabachnick and Fidell, 2014). The values are above 0.8 for all constructs, which is very good (Streiner, 2003). Average Variance Extracted (AVE) is greater than 0.5 for all constructs, thus satisfying the nominal value given by Fornell and Larcker (1981). With these three criteria fulfilled for all constructs, reliability was confirmed.

Table 3: Fornell-Larcker-Criterion.

	LE	M	SL
LE	**0.842**		
M	0.603	**0.835**	
SL	0.768	0.780	**0.853**

Discriminant validity has been measured (Table 3). The square root of AVE is higher than the correlation of these constructs, thus meeting the criterion of Fornell and Larcker (1981). Cross loadings of the items on their relevant construct (Table 4) are higher than on the other constructs.

Table 4: Cross-Loadings.

	LE	M	SL
LE1	**0.760**	0.352	0.593
LE2	**0.864**	0.551	0.662
LE3	**0.895**	0.601	0.683
M1	0.465	**0.771**	0.530
M2	0.539	**0.894**	0.760
SL1	0.530	0.540	**0.689**
SL2	0.716	0.761	**0.932**
SL3	0.717	0.661	**0.934**
SL4	0.631	0.579	**0.821**
SL5	0.625	0.769	**0.814**
SL6	0.694	0.675	**0.903**

Within the structural model analysis, inner loadings were calculated. The PLS bootstrap was used to test the significance of item loadings. Whilst the first hypothesis (SL-> LE) was significant, the second hypothesis (M-> LE) had to be dismissed (Figure 2).

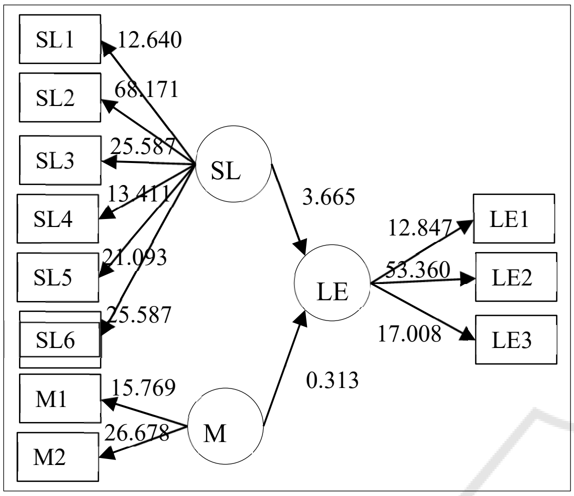

Figure 2: Path Coefficients (t-statistics for inner and outer loadings; LE = Learning Efficiency, SL = Self-paced Learning, M = Learning from Mistakes).

5 DISCUSSION

In recent literature no clear indication could be found on whether the effectiveness of corrective feedback is higher when it is immediate or delayed. But literature suggests that long delays can have a negative impact on the learning process and can overwhelm learners who need support (Mathan and Koedinger, 2005). This can explain the lower loading of "learning from mistakes" on learning efficiency that was investigated in H2. As the frustration level varies from student to student, the perception of mistakes as beneficial for the learning process and the learning outcomes varies as well. One student commented within the questionnaire on frustration resulting from mistakes: *"The work was sometimes really fun, but when errors appeared and it took time until they could be fixed or succeeding errors occurred, it was sometimes really annoying. That also spoiled the fun a bit."* (Participant 9). Another student perceived this as less problematic: "*In general, the videos, data sheets, etc. make working with SAP very easy. However, it becomes frustrating when you receive error messages that do not appear in the videos and often leave you sitting in front of the computer at a loss. With a little help from the tutor, however, this is also feasible and is therefore not a big problem.*" (Participant 28). Another student expressed a preference to increase the self-control and to even intensify the possibility to make mistakes within the scenarios: *"In my opinion, watching the videos made it a little too easy to work on the project. At one point or another, I would have liked to take more control to manoeuvre through the process in the system, so that I could make my own mistakes and learn from them."* (Participant 45).

The positive correlation of self-paced learning with learning efficiency which was assumed in H1 is in line with previous literature (Marshman et al., 2020; Bautista, 2015) and received further confirmation by the comments given within the questionnaire (Table 5).

Table 5: Some sample comments on learning efficiency of the participants.

"It helped me to understand what an ERP system is and most importantly, it brought practice to my studies, making them easier to understand."
"You learn parallel to the normal lecture (Business Information Systems), how certain processes run in the system, […] which was a lot of fun for me and helped a lot with learning!"
"Working within the environment was a lot of fun! […] I would have liked a slightly higher level of difficulty and a little more control. I learned a lot from this project and would always recommend and wish for more of this kind of learning in my studies."
"Very interesting and good way to design a course. The learning material is practically applied in a corresponding software environment. There was no dull memorization […] but rather the material was "understood". Interactive or practical design of lectures should be used more often."

Among the comments given, one student asked for more tasks, to improve understanding, e.g., another sales order requiring manufacturing of parts. There were some sound issues in the videos that required improvement and one student asked for more colour, and the possibility to visualize the progress in the roadmap (Participant 41). As suggestions for improvement are indicators for a positive attitude towards the learning environment, all of them were written down, to improve the environment for the semesters to come.

6 CONCLUSIONS

This paper contributes to the body of knowledge by providing an educational design experiment within an academic context on the complex topic of business processes and their support through ERP-systems. It could be verified that a hands-on-training within a SAP ERP-System could be taught via an e-learning environment without making compromises regarding scope or scale of the content. The student feedback gives encouragement to continue on this path. Iterative development will improve functionality, sound quality and user interaction.

Within this educational design experiment the task of providing a self-controlled e-learning environment to gain an in-depth understanding in distance learning environments has been addressed. The design was gamified, the layout showed a self-explanatory roadmap that students could follow at their own pace, completing missions and being rewarded with badges as they proceeded. Making mistakes was possible within all scenarios. If they occurred, they had an impact on the processes. Reflection was necessary to understand the causes and to identify ways for their correction. “Learning from mistakes” was supported via corrective feedback.

Within this design experiment, students could give feedback via an anonymous online survey. SEM-PLS was used for data analysis. A positive correlation of self-paced learning with learning efficiency was confirmed, while a positive correlation of learning from mistakes with learning efficiency was not supported. As the size of the data set is rather small, further research is necessary. Within e-learning environments, literature on learning from mistakes is spare. Future studies could elaborate on this. As only students taking the course qualify for participation in the survey, options for broadening the survey are limited. Further design research could broaden and confirm the results.

The invitation to the survey was linked into the learning environment at the very end. As only students who successfully completed the course came so far, the results might be biased. But the positive attitude of those students gave encouragement to continue on the path in the aftermath of the pandemic:

> *“It was a little hard for me to get into at first, but now I don't want to get out. It's a pity it's over, it was really fun.”* (Participant 6)

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