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ABSTRACT

Based on a previous analysis of game design patterns and related effects in an educational scenario, the following paper presents an experimental study. In the study a course for Basic Life Support training has been evaluated and two game design patterns have been applied to the course. The hypotheses evaluated in this paper relate to game design patterns that have been used for learning functions, expected to enhance the learning outcome and user experience. An experimental design has been carried out in order to get insight about effects of individual and combined game patterns in a Basic Life Support course. Based on the according educational objectives, the effects of two different game design patterns relevant for learning (a timer pattern and a score pattern) have been evaluated. This game was prototypically developed targeting the application on the healthcare domain (basic life support). The results show a significant interaction effect of the two patterns on the learning gain, as well as a strong covariate influence of the learners' age.

Keywords

First aid, Learning, Game-based learning, Game design patterns, Serious games

Introduction

The design of educational or serious games is a very complex process. Two antagonistic principles have to be united: the achievement of educational objectives (serious aspect) and meaningful gameplay (game aspect). Indeed, there are different instructional design approaches that help building the bridge between these two aspects. This can be achieved with the employment of pedagogical methods that overall help learner motivation, while adapting to the different requirements of a multitude of learning contexts, as will be described in the next section. However, on the more technical end of the scale, building learning games also to a large extent requires detailed technical modeling and implementation, a challenge that touches upon technical standards, as pointed out in a previous paper (Kelle et al., 2011).

One of the possibilities to structure and simplify the quest of "how to design learning games properly" is the principle of using design patterns, which have been described for instance by Björk and Holopainen (2004). This approach bears a structured and expedited approach to the design and creation of digital games. Game-patterns encapsulate common design problems and solutions for those and game designers typically combine several patterns for good gameplay. One of the main principles of game design patterns is the fact that they modulate and instantiate each other; for example, the pattern of "rewards and penalties" automatically demands the existence of some sort of "score" or "resources." Patterns can also be in conflict with each other, such as "real-time-play" and "turn-based-play." For this reason, in a game design, there generally shouldn't be conflicting patterns, because, for example, if a game is turn-based the fluent characteristic of a real-time game might be lost. For evaluation of a game design, in the end, play-testing (Schell, 2008) is necessary, which yields information on the user experience. The limitation here is that end-user testing brings the risk of not giving insight on what patterns exactly have contributed mainly to the success or failure of the game. In the experimental context, it is therefore essential to alternate between certain combinations of patterns to isolate what makes the game work and what not. Hence, for iterative game design incorporating end-user testing, this approach also bears high potential.

This paper describes an experiment based on previous research in which we have analyzed pattern-based approaches in the field of commercial game design (Björk & Holopainen, 2004), provided a mapping onto learning functions and educational objectives, and evaluated the mapping with experts in Technology Enhanced Learning. While the method of developing games with the help of game design patterns is common sense, in the field of education, evidence of the efficiency of such pattern-based serious games is scarce. In the following section the main existing findings will be discussed. After that we describe an experiment that applies two selected game patterns in a learning game and evaluate their effects on knowledge gain and user experience.

Related work

As mentioned, literature evidence for use of patterns in serious gaming is not very numerous; however, in addition to our main inspiration source for the idea of educational game design patterns (Björk and Holopainen, 2004), some other relevant leads exist, which together cover a relatively broad range of learning contexts. We will briefly give an overview of what has been reported so far by the research community.

Gunter et al. (2006) combine educational theories with a model for the design process they call RETAIN (Relevance Engagement Translation Assimilation Immersion Naturalization), which they base on well-established theories of Gagné and Keller (Gagné, 1985; Keller, 1983). The strength of this approach is argued to lie in the employment of a sound theoretical foundation relevant in motivation psychology and instructional theory. However, although the approach is pointing into the direction of drawing conclusions for the application in a pattern-based design methodology, the implementation and evaluation remains future research. Another point to be noted is that the authors address an abstract level of learning, such as the cognitive, affective and psychomotor learning domains, without targeting an actual outcome oriented learning context, specifically.

Mor et al. (2006; n.d.) choose an experience driven approach that is closer to the technical implementation side, but limits itself to the context of secondary mathematical education. They have made first experiences with using game design patterns for learning in the Kaleidoscope Project (Kaleidoscope Project, 2011), when the objective was teaching Mathematics to young learners, deriving a more general pattern based approach for the use in Technology Enhanced Learning. These findings led to the implementation of a web-based tool that enables the creation and archiving of design patterns. An example for such a design pattern would be the "crescendo" pattern that deals with the problem of emerging discussions in a learning environment, spiraling towards a more rhetorical than the (more desired) reflective mode. Again, the limitation here lies within the limitation to the mathematical domain, but at least parts of the patterns could possibly be generalized. For most patterns, evidence of their actual use in the learning context is given in a qualitative overview: for example, the crescendo pattern has been implemented and tested by Cerulli (2006), indicating a fair level of positive impact. A detailed quantitative evaluation, however, is missing.

Shute et al. (2009) used a model driven approach for assessment based learning game design, using elements like highscore and resources patterns to build their learning games. Their target audience was K-12 education level students in Mathematics. The way they used assessments to leverage the gaming aspect in their approach was by conjoining games with "embedded" assessments that are hidden from the user. They establish the term "stealth assessment," which they exemplify by modeling a competency-driven learning paradigm applied in the game "Oblivion."

Denis and Jouvelot (2005) used a best practice-based anthology of game elements in order to achieve a high threshold of motivation. Their target domain was musical education. In their approach they used a game that trained solo parts and accompaniments of certain musical pieces, training chords and scales with players taking the roles of piano players and saxophonists in pairs of two (duets), controlling the musical interface by means of standard computer gaming equipment like joysticks and gamepads. A fair deal of freedom was given to the players, enabling improvisation, giving them ownership of their interactions.

Dickey (2006) looked at Massively Multiplayer Online Role-Play Games (MMORPG's), and determined several elements that take a key role for player motivation. In his overview, he outlines the element role-playing that is responsible for a high identification factor of the player and the game character. Furthermore, a high emphasis is put on the element of narrative structure, which guides the activities of the player, being responsible for a high intrinsic motivation. As a particular element relevant for the learning context is the presence of quests that address the problem-solving aspect.

The notion of design patterns for educational games can be found more explicitly in the work of Huynh-Kim-Bang et al. (2010), in which several patterns are drawn from the analysis of 20 serious games examined by the authors. They describe the following patterns: Serious Game, Game-Based Learning Blend, Instructive Gameplay, Time for Action/Time for Thought, Reified Knowledge, Museum, and Fun Reward.

These patterns rank on different abstraction levels: While the first three patterns address a very broad spectrum of educational gaming, the latter four target more concrete dimensions. Time is identified here as axis both relevant for a more intensive “action-based” gaming experience in which the player has to deal with tasks in a rapid way. On the other hand, this is counterbalanced with more contemplative phases, which yield time for thought and reflection. The pattern of Reified Knowledge, however, drives more into the direction of self-awareness of the user’s progress in the game, by manifesting certain virtual objects that represent goals and results of the game learning process. Finally, the Fun Reward pattern aims at game elements that trigger motivation for the user’s incentive to keep playing. Overall, the approach in this work provides a useful insight on how to create meaningful connections between learning and gaming. The authors state in the conclusion, however, that there is the lack of external validation.

Finally, Kiili puts forward another promising approach by aggregating a collection of educational game design patterns on his website (Kiili, 2011). His typology of patters comprises several categories: Integration Patterns, Cognition Patterns, Presentation Patterns, Engagement Patterns, Social Patterns and Teaching Patterns. For each of these categories at least one pattern has been collected so far. This pattern library is open to suggestions for new patterns and as such could become an important repository for the community of educational game designers.

With the exception of the approaches of Mor et al. (2006), Huynh-Kim-Bang (2010) and Kiili (2011), in the approaches listed above the actual formalization of game design patterns is either not very concrete, or targeting a too narrow scope to be generalized, transferred and re-used (which is really the main purpose of design patterns). The main advantage of these findings, however, is that there are several leads that point into the direction that a pattern-based approached enhances design methodology with a direct positive impact on user experience and learning outcome

Using the definition described by Mory (2004): “a process in which the factors that produce a result are themselves modified, corrected, strengthened, etc. by that result” and “a response, as one that sets such a process in motion,” the most relevant aspect is the notion of feedback for self-regulated learning, which was discussed in detail by Butler and Winne (1995). According to them, the mirroring of feedback to the learner is of high importance to affect cognitive engagement with tasks, using feedback of intermediate and total achievements in the learning process. The reason for this lies in the fact that an improvement of the learning experience and outcome can be measured positively if learners are given the possibility to monitor and gauge their own progress during their learning activity. As described by Verpoorten et al. (2010), this condition allows the learners to scrutinize and reflect about their newly acquired knowledge, a process which has the potential for a lasting learning success.

Revisiting Kiili, more considerations are raised with respect to feedback-induced reflection in learning game scenarios. Kiili (2008, 2011) eclectically argues for reflection as key principle in learning games. He proposes a methodology called “Reflection Walkthrough” that is derived from the user evaluation principle of cognitive walkthrough, in order to isolate potential strengths and weaknesses of a learning game design. The methodology gives insight on feedback mechanisms that trigger reflection, the support of double loop learning, and the potential risks of evaluation overhead and cognitive overload.

As a challenge that summarizes these aspects and motivates our research we quote the recommendation for future research stated by Mory (2004): “Continue to identify and test interactive patterns among the learner, the environment, individual internal knowledge construction, and varying types of feedback.”

Preparations and research questions

In our previous research, extending the work of Gunter et al. (2006), as well as Kiili (2008, 2011), we looked at several pedagogical theories and taxonomies (Kelle et al., 2011), which form the bridge between game design and learning goals and functions. The method employed for this “bridging” was a step-by-step algorithm that was evaluated with 10 experts in instructional technology who independently of each other mostly came to the same results for a pattern matching between educational and game design patterns. Different from Kiili’s method of

Reflective Walkthrough, we focused rather on the preparatory end of sound learning game design than post mortem evaluation.

In this expert we had asked our 10 experts to rank the matching of a choice of game design pattern with different learning functions. The results from these expert evaluation study led us to the selection of specific patterns, i.e., the so-called time limits pattern and score pattern and that these are especially well suited for the “monitoring” learning function, which enables the reflection of learning (and game-) progress to learners. It turned out that the score pattern achieved an average ranking of 4.64 (out of 5) for the learning function of “monitoring,” and the timer pattern achieved a ranking of 4.2. These patterns can be found in Björk and Holopainen’s compendium about game design patterns (Björk & Holopainen, 2004), and are described as follows:

- The time-limit pattern is described as the pattern *for completing an action, reaching a goal, staying in a certain mode of play, or finishing a game session with a limit based on either game time or real time.*
- The score pattern is described as *the numerical representation of the player's success in the game, often not only representing the success but also defining it.*

These patterns individually also showed to have a relatively big disagreement factor compared between the experts’ ratings. We wondered about this and therefore decided that this requires further examination.
In the experiment for this paper we have used a classic model of three experimental groups and one control group which account for the different possible combinations of both time-limit and score pattern (for details see method section). Henceforth, we refer to the different treatment groups as such:

- T0 is the control group in which none of the patterns have been applied.
- T1 is the group that only has been exposed to the time-limits pattern.
- T2 is the group that only has been exposed to the score pattern.
- T3 is the group that has been exposed to both score and time-limits pattern.

As target domain the medical topic of basic life support and first aid was chosen, because the topic is relevant, indifferently of demographical factors, for the simple reason that everybody is at permanent risk to run into an emergency situation of serious gravity (either as victim, causer or bystander). We thus controlled the risk of introducing a bias of intrinsic demotivation due to possible lack of interest in the learning content. As source for the learning content we took the guidelines available on the European Resuscitation Council’s website (ERC, 2010).

The objective of the learning activity in this experiment was the training and re-activation of basic knowledge relevant for the learner’s reaction speed and quality of decisions in emergency situations that require a first-aid response. Hence, the main educational objectives beside knowledge gain and refreshment of existing knowledge were fast reaction times. The relation to the learning function “Monitoring,” which was strongest rated by the experts in our preparatory study was also considered for the choice of patterns applied. Monitoring in this case entails the reflection of progress and success, mirrored to the learner throughout the progress of the game. Therefore, the choice of game design patterns for this experiment was narrowed down to what could possibly best link to the main learning goals: improvement of reaction speed and quality of responses and creating corresponding in-game awareness thereof.

In order to cater for an elicitation of high response quality, mirroring of the user’s performance was needed. The most obvious way to do that was to display a game score during the experiment; in order to enhance reflection for motivation and self-awareness, as consequence of a self-monitoring learning function. The users could thus monitor their performance and gauge their own skill levels on the fly. The other objective of interest was fast reaction time. Here, the best matching design pattern was the time-limits pattern, implementing a game element that creates a time constraint and displays a timer to the user. In order to advance in the game successfully, the user interaction had to be performed inside that time limit (in our case, 60 seconds per game unit). While the level of realism in our serious game indeed was not the highest due to technical limitations, the time limit introduced a certain notion of stress, which according to Svenson and Maule (1993) can have an effect on decision framing (the opposite decision can be taken if under time pressure). In our case the purpose was to create a more realistic scenario as well as train the users for quick decision-taking. According to Zur and Bretznitz (1981), time pressure also can have the positive influence on a subject to take decision that is *less* risky than taken without time pressure.

The main objective of our experiment was to evaluate effects on knowledge gain and motivation catalyzed by the time and score patterns applied on learning content.

The research questions and hypotheses derived hereof are stated as follows:

(1) Will the knowledge gain of participants be significantly increased by the application of the timer and score design patterns?

    Hypothesis. Knowledge gain will increase when both patterns are applied, in comparison to the application of only one pattern, or with none pattern, such that the knowledge gain of T3 will be bigger than of T2 and T1, and the knowledge gain of T0 is smallest..

(2) What is the role of age of participants, and previous knowledge related to medical, computing and computer gaming experience? What are correlation effects and covariates?

    Hypothesis. We expect that the effects of time and score on the knowledge gain are independent of other variables like age, previous knowledge and computer gaming experience.

(3) What impact can be measured for the user experience in different groups and subsets of groups?

    Hypothesis. The application of game design patterns have a positive impact on user experience which we monitored in further dependent variables like perceived suspense, perceived knowledge gain, enjoyment and users' score in the game.

Method

In the operationalization we used two independent variables, i.e., we combined the use of the time-limit pattern and the use of a score pattern applied to the learning content. This resulted in four different treatments combining the two levels of the variables. Regarding the treatment groups, a 2x2 matrix design with 3 experimental sample groups and one control group could be formulated (cf. table 1).

Table 1. The different treatments / samples

	Time-Limit Display On	Time-Limit Display Off
Score Display On	T3 = ScoreTime Both time limit and score pattern	T2 = Score Only score pattern
Score Display Off	T1 = Time Only time limit pattern	T0 = Control No game design pattern

As dependent variables we measured knowledge gain, user appreciation, game score, and perceived knowledge improvement. These dependent variables were measured with tests after the treatment (in the case of knowledge gain: before and after). Furthermore, we calculated the knowledge gain by using questionnaires applied before and after the treatment, making use of

- multiple-choice questions for scenarios upon encounter of a victim in traffic, indoors, outdoors, and revival scenario,
- test questions for terminology of AED (Automated external defibrillator) and CPR (Cardio-Pulmonary Resuscitation), as well as how to perform CPR

The knowledge gain was calculated as the difference of the sums of the number of correct and incorrect answers (see formula in results section). User appreciation was measured in terms of enjoyment of users rated on a Likert-scale. The game score was the actual final score the users achieved in the game, and perceived knowledge improvement was a self-assessment of confidence about the user's knowledge, on a Likert-scale. To complete the portfolio of dependent variables, we also focused on user experience, and asked the users how suspenseful they found the game, and how well they had understood how the game works.

As control variables demographic information and previous experiences with computer games and Basic Life Support has been ascertained in the pre-questionnaire.

In total 133 subjects participated in the study. These 133 subjects formed 4 different treatment groups, randomly assigned according to the experimental design. In group T3 there were 36 subjects, in group T2 there were 38 subjects, in Group T1 there were 35 subjects and in group T0 there were 24 subjects. Overall, there were 47.4% of female participants and 52.6% male, with similar group distributions. The average age of participants was 32.87, and 62.9 % had a university degree or higher education level.

Table 2. Report about descriptives of test samples

GroupString		Age	CompLit	CompGameLit	Med_knowl	FirstAid
Control	Mean	41.52	3.3750	2.4800	2.68	1.80
	N	25	24	25	25	25
	Std. Deviation	14.295	.82423	1.41774	.988	1.472
Score	Mean	28.05	3.6842	3.5789	2.79	1.13
	N	37	38	38	38	38
	Std. Deviation	6.105	.87318	.94816	.811	1.143
ScorTime	Mean	34.36	3.7838	2.7667	2.57	1.30
	N	36	37	30	37	37
	Std. Deviation	10.450	.94678	1.22287	.987	1.175
Time	Mean	30.23	3.7143	3.2857	2.37	.69
	N	35	35	35	35	35
	Std. Deviation	9.726	.75035	1.04520	.843	1.207
Total	Mean	32.86	3.6642	3.0938	2.60	1.19
	N	133	134	128	135	135
	Std. Deviation	11.125	.85790	1.20653	.908	1.277

The age distribution per group was differing in the treatment groups, due to the random assignments: Participants were older in the control group where the average age was 41 years, with the highest standard deviation. Overall there were 76 participants from Asia, 22 from America, and 35 from Europe, fairly well covering a broad range of different backgrounds. In the pre-test questionnaire, participants were also asked to give detail about their previous experience and knowledge about the topic. There was an average medical knowledge of 2.6 (out of 5), computer literacy of 3.7, and computer game literacy of 3. Most participants previously had taken none (35%) or one (37%) first-aid course (cf. table 2).

The knowledge gain was calculated as follows:

$$K_{gain} = \sum S_{post} - \sum S_{pre}$$

with S_{post} denoting the score (S = 0 if incorrect, or S = 1 if correct) of correct answers given in the post-test, and S_{pre} denoting the score of correct answers given in the pre-test. If the sum of correct answers was higher in the post-test than in the pre-test, it meant there was a positive knowledge gain. If it would have been lower in the post-test than in the pre-test there would have been a negative number as result, which would mean that somebody knew “less” than before.

Apparatus

The experiment was implemented by using the Emergo (Nadolski et al., 2008) Toolkit, which is a java-based application framework and authoring environment for web-based learning games. For our aims this solution provided the right characteristics, because it was possible to create a learning game experience that has almost no distraction elements (user registration dialogs, social network feeds, etc.). In figure 1 and 2 it is shown how the two different patterns were realized in the user interface.

Figure 1. The timer bar is diminishing as time progresses. This simulates a certain urgency of the choice to be made. The score is being reflected as well, which enables participants to gauge their performance on the fly.

Results

Hypothesis 1. Knowledge gain will increase when both patterns are applied, in comparison to the application of only one pattern, or with none pattern, such that the knowledge gain of T3 will be bigger than of T2 and T1, and the knowledge gain of T0 is smallest.

While the biggest knowledge gain could be measured when both patterns were applied, the second-best learning result was achieved in the control group where there were no patterns applied. Table 3 shows the knowledge gain results.

Table 3. Average values of knowledge gain according to the 4 different combinations of 2 patterns

	Score on	Score off
Time on	KnowGain = 1.9167 Std. Deviation = 1.79483	KnowGain = 1.4286 Std. Deviation =1.57715
Time off	KnowGain = .9211 Std. Deviation =1.32301	KnowGain = 1.6667 Std. Deviation =1.43456

A univariate analysis showed significant effects when measuring between-subjects effects on knowledge gain (F = 5.104) at a significance of p = 0.026 for the combined treatment with both patterns, while the knowledge gain for both treatments with only 1 pattern or the baseline without any pattern was not significant (cf. table 4).

Table 4. Tests of Between-Subjects Effects on Knowledge Gain

Group	F	Sig.
T0 (control group)	.506	.478
T1 (time limit pattern applied)	1.924	.168
T2 (score pattern applied)	.222	.638
T3 (both patterns applied)	5.104	.026

With respect to hypothesis 1 the result showed that the hypothesis could be verified only partially. While the application of both patterns elicited the highest knowledge gain significantly, the other treatments had no significant knowledge gain; with the time limits pattern ranking second. This hints at a strong combination effect of both patterns.

Hypothesis 2. We expect the effects the time and score patterns on learning gain to be independent of other variables as age and previous knowledge, and computer game experience.

Here, we found that the age correlated (between subjects) significantly with knowledge gain in the groups for the treatments of both time and score patterns (p = 0.006), as well as with only the time pattern (p = 0.044), while the control and score groups did not show such a significant correlation. It is also remarkable that there was no significant correlation between previous medical knowledge as well as computer literacy of the participants and knowledge gain.

Table 5. Analysis of Variance, using Age as covariate

Group / Covariate	F	Sig.
Age (covariate)	8.960	.003
T0 (control group)	.535	.466
T1 (time limit pattern applied)	2.928	.090
T2 (score pattern applied)	.110	.741
T3 (both patterns applied)	.619	.433

The correlation between number of times of already taken first aid courses and knowledge gain showed to be significant in the control group, thus indicating that the absence of game patterns is best for those subjects who had taken already several first aid courses. For people who had already a fair deal of computer gaming experience, a significant correlation was found in the group for the treatment with the score pattern.

Using a covariate analysis we established that there was a significant effect of age on the results, which appeared to occlude the actual effect on knowledge gain (see table 5, the effect of the age was large and highly significant with F = 8.96 and p = 0.003). Consequently, we split the test population in halves, at the median of the age of 30 (size of subgroups was slightly bigger in the group of younger participants with ratio 71/62). We then tested again for significance of the effect of the treatments on knowledge gain, for younger and older participants separately (cf. table 6). The results showed that there was no significant effect of any treatment on the knowledge gain in the set of younger participants, but the effect on the knowledge gain of older participants was significant in the subgroup that had the "time limit" treatment (F = 6.835, p = 0.011).

Table 6. Analysis of variance using age split

Age split	Group	F	Sig.
young	T0 (control group)	.791	.377
	T1 (time limit pattern applied)	.291	.592
	T2 (score pattern applied)	.045	.832
	T3 (both patterns applied)	1.223	.273
old	T0 (control group)	.354	.554
	T1 (time limit pattern applied)	6.835	.011
	T2 (score pattern applied)	.797	.376
	T3 (both patterns applied)	1.832	.181

This result indicates that the hypothesis 2 was refuted with respect to the strong covariate influence of age of the participants. After decomposing the sample into subgroups regarding the age split of "young" ≤ 30 and "old" > 30 years it was only the time-limits pattern that showed significance in the older set of participants.

Hypothesis 3. The application of game design patterns have positive impact on user experience which we monitored in further dependent variables like perceived suspense, perceived knowledge gain, enjoyment and users' score in the game.

To examine results for this hypothesis (cf. table 7), we tested effects on rather experiential dependent variables. It turned out that the effect on actual points achieved in the game was significant in the group of older participants that had received the treatment with both time and score pattern (F = 5.411, p = 0.024), while in all other groups and subgroups there was no significant effect on points achieved.

Table 7. Analysis of experiential dependents, using age split

Age split	Group	Score		Suspense		Perceived Knowledge Gain	
		F	Sig.	F	Sig.	F	Sig.
young	T0 (control group)	.005	.943	.839	.363	.079	.779
	T1 (time limit pattern applied)	1.210	.275	2.566	.114	.004	.949
	T2 (score pattern applied)	.226	.636	.180	.673	.208	.650
	T3 (both patterns applied)	1.210	.275	7.516	.008	.008	.930
old	T0 (control group)	2.522	.118	1.554	.217	.418	.893
	T1 (time limit pattern applied)	.350	.557	.015	.902	.954	.333
	T2 (score pattern applied)	.003	.960	.365	.548	7.519	.008
	T3 (both patterns applied)	5.411	.024	2.363	.130	7.065	.010

Another dependent variable was linked more closely to user experience: The participants were asked how much they had enjoyed playing the game. Here, no significant effect could be measured in any group (therefore not listed in table 7). However, when asked about how much suspense they had felt during playing the game, a significant effect ($F = 7.516$, $p = 0.008$) could be measured in the group of younger participants that had received the treatment with both score and time patterns.

Interestingly, looking at perceived knowledge gain, in the group of older participants the treatment with the score pattern showed a significant effect ($F = 7.519$, $p = 0.008$) and the treatment with the time and score pattern showed a significant effect of similar value ($F = 7.065$, $p = 0.01$). There was no significant effect in any other variables and treatment groups, or in the subgroups of younger participants.

Discussion and conclusion

Looking at the main question of this research, i.e., if the combination of both patterns has positive effects on knowledge gain and user experience, the results show overall the tendency that this is the case, especially for participants of older age. On the one hand, this stresses the fact that game design patterns should not exist alone; indeed, by the very nature of their definition according to Björk and Holopainen (2004), choosing one game design pattern in most cases automatically requires the presence of other game design patterns, and so forth, inductively. The fact that we observed in our limited setup that already the presence of two game design patterns exhibited a significant combination effect on user experience and player score points towards the importance of interlinking such patterns and make them supplement each other so they provide a sound, holistic game design that suits the respective context.

With respect to the strong influence of age, it appeared at first that isolated game patterns have an even lower value than no game pattern at all when being applied to “gamify” learning content. It quickly became clear that age had a significant covariate effect that influenced the main result. It was, hence, necessary to analyze the data more in-depth, with splitting between younger and older participants at the median value of 30. This revealed that the first observation could only partially be confirmed. A significant effect on knowledge gain then only could be monitored for the treatment with the “time limit” pattern, indicating that stress induced by a timer has a positive influence on knowledge gain for older participants. An informative addition to this observation could be made when not just looking at knowledge gain, but also at other dependent variables. Indeed the actual score reached in the game and perceived knowledge gain showed significant benefit in the group of older participants who had the treatment with both score and time patterns.

It could also be observed that younger participants showed a fair deal of inertia with respect to the effect of different treatments on learning outcome. What was interesting, however, was that the treatment with both patterns in the younger group was perceived as most suspenseful. A potential interpretation of these findings could be that younger participants take more notice of the gameplay as such while not being as responsive with respect to the intended learning objective. While correlations might partially give insight to the reasons of the significance of effects on knowledge gain when looking at the whole test sample, the correlations were no longer significant after splitting between younger and older participants. This indicates that in future research quasi-randomization with equal age distributions in all treatment groups will be required.

Subsuming, our result has limitations because we only tested two patterns and the result was not significant for the younger half of the test sample. Future research in this direction should therefore try different contexts with different patterns, with particular awareness of age of the participants, and extend the fundus of data with similar or bigger sample sizes.

The theoretical background of this study, which largely foots on the paradigms of feedback and reflection, seems to withstand being put to the practical test. This can be concluded because the suggested benefit of design patterns for the gamification of learning content could be validated especially in the self-directed learning context, which is more relevant to older participants. It is, however, necessary to disclaim that our target domain of basic life support and first aid training usually is organized in a quasi-curricular fashion under the surveillance of expert instructors. The intrinsic motivation, though, to enroll for first-aid training, tends to be higher for more mature participants, as the necessity for such undertaking depends more on personal insight and experience. As such, design patterns for learning games seem to be well suited for the life-long learning context.

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