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A Dynamic Bonus System to Increase Player Participation in Pervasive Learning Games

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Abstract: A pervasive game blends gaming with the real world and makes the experience pervasive according to the players' everyday life. Pervasive games typically last for days or weeks and have successfully been used within advertising and social relationship building. A pervasive learning game intentionally removes the walls of the classroom and makes learning something that happens everywhere at all times. However, lessons learned in previous research on long-lasting pervasive learning games have shown that not all players/students participate enough in the game to achieve the desired learning outcome. The-Last-Shall-Be-The-First (TLSBTF) is a method to overcome this problem by rewarding players that activate passive players. Activated players also receive special bonus that – given that they from this point on actively participate in the game – gives them the opportunity to get ahead and even win the game. The method has shown promising results in experimental long-lasting pervasive learning games. In this paper, the method is refined and presented as mathematical formulas. Formulas make it easier to integrate the method into similar types of games. Another important contribution is the clarification of the elements of the model behind the method that makes it easier to conduct research on the effect of the individual parameters in relation to increased player participation in long lasting pervasive learning games. Furthermore, the mathematical formulas presented in this paper, provide a good platform for further development of the TLSBTF method. The main contribution of this paper is the presentation and description of the mathematical model that make up the dynamic TLSBTF bonus system method.

Keywords: Pervasive games, Education, Serious games, Player Participation, Dynamic Bonus System

1. Introduction

The game Pervasive Clue from 2001 is probably the first to be labelled as pervasive (Nieuwdorp, 2007, Schneider and Kortuem, 2001). According to (Montola et al., 2009), the name "pervasive game" was coined in the same year – to categorize alternate reality games such as The Beast (Beast, 2020). For some years this has been described as a new and emerging genre and many different games, activities and experiences have been labelled and defined as pervasive. Even though the terms pervasive game and pervasive gaming are widely used, there is no unifying definition. Different researchers approach pervasive games from different perspectives, defining the term based on the technology that enables the game to be played, or the game itself (Nieuwdorp, 2007). The work presented in this paper uses the following definition of a pervasive game:

A pervasive game is a game that is pervasive according to the player's everyday life.

This definition removes the technological aspect and links the definition to the player and the player's daily life. This means that pervasive gaming is not limited to the contractual space of the traditional magic circle of gameplay, the technology used or the physical location where the game is conducted, but deduces that participating in a pervasive game influences the player's ordinary life directly (Montola, 2005). It can be argued that this is an incomplete definition since the term *pervasive* is used recursively, however, for a game to become pervasive it has to be pervasive according to something.

Lessons learned when using pervasive games within the field of game based learning has shown that in games that last for a long time, for several days such as HiNTHunt (Pløhn and Aalberg, 2013) or several months such as Nuclear Mayhem (Pløhn, 2013), some players are less motivated and therefore participate less. This is of course problematic as it influences the learning outcome. There may be many reasons why some players are less motivated or for other reasons choose to not participate actively in the game. One reason that was identified during the two runs of the experimental pervasive game HiNTHunT, a game designed to be used the first week of the academic year to prepare new students for their new life as students, was that some players lost their motivation because they were late to start the game and then discovered that other players already were far ahead. The following quotes from the questionnaire that players had to fill in after completing HiNTHunt, identify that several players lost motivation because they had a bad or delayed start and consequently fell behind other players in the competition (quotes are translated from Norwegian):

- *"I found the game a bit messy at first, and once I understood the game, the others were far ahead. So, I decided not to play."*
- *"The reason why I did not play the game as much as I was supposed to was that I got off to a bad start."*
- *"I got off to a bad start since I had some problems with the Internet on the phone. The others eventually came so far ahead that I lost interest in the game."*
- *"Started at school later than the rest and was therefore too late to participate properly in the game."*
- *"If I had played it from the very start, I would probably have played it more."*
- *"For me to participate more in the game I would have needed a better start."*

As a means to engage passive but initially motivated players, we designed "The-Last-Shall-Be-The-First" bonus system (TLSBTF). This is an approach to give passive players a chance to advance from the bottom to the top of the result list given that they become engaged in the game afterwards. TLSBTF is designed primarily as a means to increase player participation in pervasive learning games but may also be useful in other games with similar characteristics.

Our paper is organized as follows. In section 2 we provide an overview of related work. In section 3 we introduce how TLSBTF was implemented using a static model in the game HiNTHunt and present some experiment results. In section 4 we present a dynamic model of TLSBTF using variables from the game and the overall state of the game. Finally, we conclude and suggest further work.

2. Related Work

Two terms that correlate directly to the level of player participation in games are *player engagement* and *player enjoyment*. If a game is perceived as a fun game to play, players are more likely to spend time on the game. A systematic review examining how engagement has been measured and defined is presented by Hookham and Nesbitt (Hookham and Nesbitt, 2019). They describe engagement as a multi-dimensional construct and define a three-part framework looking at the cognitive, behavioural and affective dimensions. Three primary uses of engagement are identified: engagement referring to use (the player is engaging in or with an activity or game), engagement referring to a player state (the player is engaged), and engagement referring to the property of a game or object as engaging.

Enjoyment in games is often discussed in the context of The GameFlow model (Sweetser and Wyeth, 2005) which is a model that maps elements of gaming to (Csikszentmihalyi, 1990) elements of flow. Work done on evaluating the GameFlow model in relation to pervasive games as a means to understand player enjoyment in pervasive gaming (Jegers, 2007), concludes that the GameFlow model is appropriate for gaining understanding of player enjoyment in pervasive games. This led to the outline of a model – the Pervasive GameFlow model – that can be used as both heuristic guidelines for designers and as evaluation criteria in user-centred evaluation of pervasive games (Jegers, 2009).

The use of virtual characters in serious games has shown to have a significant positive effect on player engagement (Gamage and Ennis, 2018), however this is not a design strategy for pervasive learning games where much of the game play takes place in the real world and the players play as themselves.

Several approaches have been used to try to increase player participation in pervasive games such as storytelling (Pløhn et al., 2014), awareness reinforcement (Pløhn et al., 2014, Pløhn and Aalberg, 2014), group competition (social pressure) (Pløhn and Aalberg, 2014). The Pervasive GameFlow model consists of eight core elements and HiNTHunt – the game where we have implemented The-Last-Shall-Be-The-First-Bonus-System (TLSBTF) – is designed according to these elements (Pløhn and Aalberg, 2014).

3. The-Last-Shall-Be-The-First Bonus System

The main purpose of The-Last-Shall-Be-The-First-Bonus-System (TLSBTF) is to target the group of passive players that would have been motivated to participate actively in the game if they had got off to a better start.

The main hypothesis is that if a passive player gets a bonus that outweighs or cancels the negative effect of a bad start, he will assert himself in the competition as much as players that got a good start. Players that participate actively in the game from the moment they have been targeted by the TLSBTF system, will be transformed from unmotivated to motivated players resulting in overall increased participation in the game. The main strategy behind TLSBTF is to use motivated players to engage those who are less motivated, by providing a game mechanics to engage passive players to perform actions in the game. Hence, a prerequisite for the model is that some of the players in the game must be what we define as “eager players”, that is, highly motivated players who assert themselves in the individual competition and are willing to perform actions that award them game points. If this is the case, we can use “eager players” to trigger TLSBTF and target the passive players.

TLSBTF was implemented in the second run of the experimental pervasive learning game HiNTHunt to test if the above hypothesis and prerequisite were valid assumptions. In this experiment, TLSBTF was implemented as a static system where all game points awarded were constants hard coded in the implementation. All passive players received the same amount of bonus points if they were targeted successfully by TLSBTF, not considering their individual situation in the game competition. This value was based on an estimate of how many game points that would be “enough” for the passive player to advance significantly on the result listing. The eager player was also awarded with game points if they targeted a passive player successfully, but received significantly less points than the passive player. Ideally, the reward for an eager player should be as low as possible and just enough to motivate them to target a passive player. In this experimental run, the value was set to the same value as ordinary game related activities. Which players were considered as passive players was decided by the high score list at any given time. A list of the 10 least engaged players at the given time (passive players), was generated by picking the 10 players at the bottom of the high score list. They were presented as “bonus players” that could be targeted by other players to gain bonus points. Hence, the size of the group of bonus players was also a constant value and not adjusted for the overall number of participants or any other variables in the game. In the game, there was both an individual competition and a group competition between two school classes and the bonus list was generated without regard to group competition. The bonus list consisted of the ten bottom players in the individual competition regardless of which group they belonged to.

How to generate the group of bonus players, the size of the group, which players should be part of the group, and how it should be organized to not have an unwanted or negative effect on other parts of the game or the competition, requires more work and more research. However, in terms of testing whether TLSBTF would have an impact on player participation, this way of generating the bonus list was an adequate solution.

TLSBTF was implemented in quite a simple way in HiNTHunt. The game client showed a list of “bonus players” that active players could attempt to engage by performing a game related activity. This activity consisted of getting the passive player to register a unique code that was generated by clicking the passive player’s name in the bonus list. When the action was completed successfully, both players received game points, but the passive player received significantly more bonus points than the active player. The process is illustrated in Figure 1.

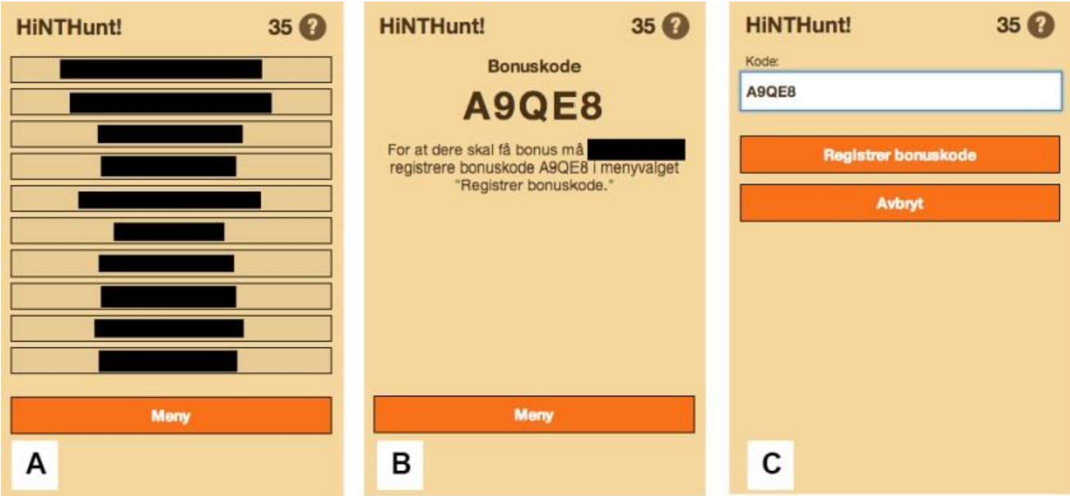

Figure 1 - (A) The dynamic bonus list shown in the game client (the names have been redacted due to privacy rules). (B) The active player has clicked on one of the passive players listed and revealed a five-digit unique code that the passive player has to register in his/her game client. (C) The passive player is registering the code in his/her game client after being told the code by the active player.

In the first run of HiNTHunt (without TLSBTF), 49 students registered as players and in the following year, when TLSBTF had been implemented, 45 students registered as players. All players had to fill in a quantitative questionnaire and data was also gathered by analysis of system logs of player activities and by observations. In the duration of HiNTHunt, TLSBTF was successfully used 111 times. Analyses of data from the questionnaire and log files suggest that passive players that were successfully targeted by the bonus method, became more motivated to participate in the game.
Analyses of log files showed that they became more engaged in the ordinary game play (collecting diamonds) compared to the previous year. Replies in the questionnaire also suggested that they became more motivated to participate in the game. 63,3% stated that being targeted by bonus system made them more motivated to play the game. So, even the simple and static implementation of TLSBTF in HiNTHunt, shows that it is a promising method to increase player participation and to transform passive into active players. However, there were some unintended effects and problems that need to be addressed.

For new students who did not yet know each other by name, TLSBTF use was less than optimal because it was difficult to identify players on the bonus list (which only displayed names of the players). This problem can easily be addressed, for example, by requesting players to upload a picture of themselves in the game and display this picture along with the name when a player is targeted.

A more fundamental challenge is that the bonus system influenced the intended normal game play in a negative way. Regularly collecting diamonds became less important as a game play strategy and some actively chose not to participate in the game in order to be targeted by TLSBTF as much as possible. Then towards the end of the game, they would collect all remaining ordinary game points. The player that came in second in the individual competition, and several others, followed this strategy. To avoid this, the amount of bonus that passive players receive must be adapted to the overall situation in the game. Active participation in the ordinary game play from start to finish, should always be the most rewarding strategy. To achieve this, the bonus must be dynamically adjusted based, for example, on the passive players' situation, the other players' situation, the status of the game in relation to how many game points have been awarded and how many possible game points remain in the game.

Another challenge we faced was that the group competition in HiNTHunt had an unintended effect on the bonus system and caused it to be activated less than optimal. As described above, the bonus list was generated without considering the group competition. The 10 bottom players from the high score list were presented as "bonus players" that could be targeted by other players. However, because the group competition was perceived as important, active players were reluctant to target "bonus players" in the other group to avoid giving extra points to others. Possible strategies to solve the problem of group competition having a negative effect include ignoring bonus points awarded in the group competition. Unfortunately, activating players in the opponent group will still be unfavourable because the activated player will start collecting regular points.

Another strategy might be to generate bonus lists for each group containing only players from the same group. This, however, removes the group competition reasons for activating passive players. Size of the groups is another issue that needs consideration. Two groups of different sizes should maybe have different number of bonus players presented on their group bonus list or perhaps a more just solution would be for the bonus list to show a percentage of bonus players according to the size of the given group.

It is obvious from our experience that the proposed TLSBTF bonus systems need to be carefully designed and adapted to make up a fair system that contributes to the overall purpose of the game, which is to motivate and engage all students. The bonus system should not dominate as a game play strategy and thus have a negative influence on the main game play, and the bonus system needs to function well together with other game elements such as group competition. Which solution that is optimal is not known, and is a topic that needs further research.

4. The-Last-Shall-Be-The-First Dynamic Bonus System

To develop TLSBTF further and make it suitable for different pervasive games, it must be changed from a static model designed for use in one specific game, into a dynamic model that uses commonly found variables to adjust and calibrate itself according to the changing state in the game. A dynamic TLSBTF model will also provide better opportunities to conduct research on the effect it has on player participation as well as allow for further systematic development of the method. The refinement from a static model to a dynamic model that can be implemented in other pervasive games is presented in this chapter.

In order to design a dynamic TLSBTF model, we must first identify variables that commonly will be present in such games. Then we need to investigate if these can be used to construct a model that makes the bonus system dynamic in relation to the game situation at any given time. At the same time we need to be able to use the variables to optimize for ordinary game play combined with effective use of the bonus system to activate passive players.

We have analysed the long-lasting pervasive games HiNTHunt and Nuclear Mayhem and identified the following variables that commonly will be present in long-lasting pervasive games. A selection of the most significant variables is shown in Table 1.

N_a	Number of active players
N_u	Number of passive players
N_{tot}	Total number of players
NP_g	Total number of players in a given group g when there is a group competition
P_M	The score of a motivated player at a given time t
P_U	The score of an unmotivated (passive) player at a given time t
HS	Highest score in the high score list at any given time t
HS_{min}	Lowest score in the high score list at any given time t
HSG	Highest score in group g in the high score list at a given time t
HSG_{min}	Lowest score in group g in the high score list at a given time t
MAX_{end}	Maximum number of points possible in the game from start to finish if one gets all the points
MAX	Maximum number of points possible in the game from start to a given point t
REST	Available remaining points for a specific player
BG	The number of P_u to be included in the bonus group
BG_g	The number of P_u to include in the bonus group from a given group g if the bonus list shall be group orientated (it's not certain that all groups should have the same size)
t	A given time t in the game
t_{total}	Total duration of the game from start to finish (if the game has a defined end time)
t_{rest}	The remaining time from t to t_{total}
BG_g	Number of players in BG (bonus group) for group g
BG_{gmax}	Highest score of the players included in the bonus group
BG_{gmin}	Lowest score of the players included in the bonus group
MP_{limit}	When a P_u receives a bonus boost, he/she must not get higher up on the high score list than MP_{limit}

Table 1 – Identified variables present in all types of long-lasting pervasive games

The game HiNTHunt2013 used a set of *constant bonuses* for the players involved in a successful TLSBTF interaction. The aim of the current paper is to extend this to a *dynamic bonus system* by introducing a mathematical ratio model. The model is based on elected variables from Table 1 and the overall game situation illustrated in Figure 2.

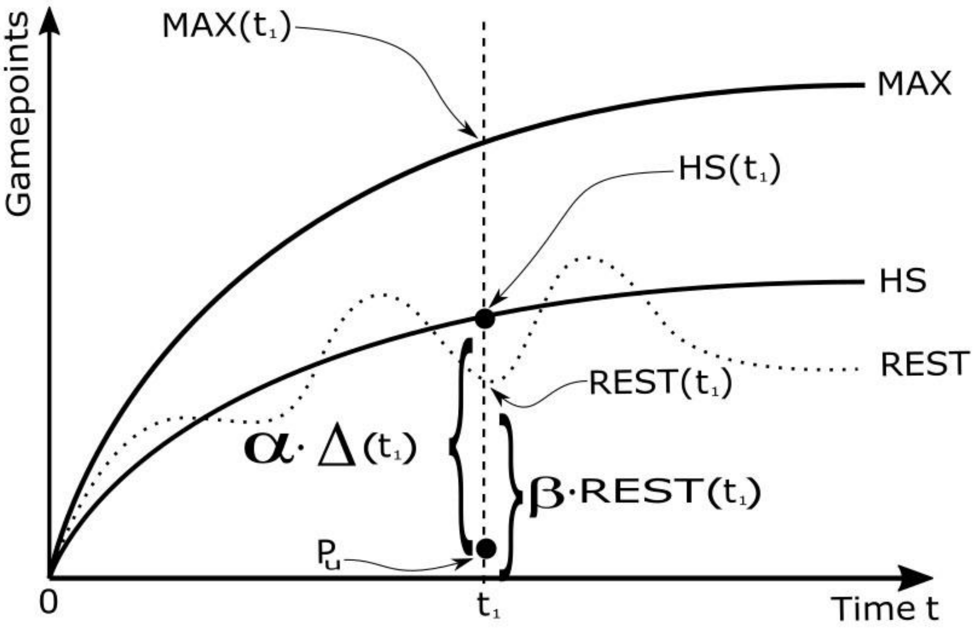

Figure 2 - Illustration of the relevant variables at a certain game state at the point where the unmotivated player receives a bonus based on these variables.

The game starts at t=0 at the left side of the figure and evolves from left to right as t increases. MAX illustrates the maximum point a player can get if he/she plays the game perfectly and collects all possible game points. HS is the high score in the game at any given time. REST illustrates the available remaining game point at any time for a specific player. REST fluctuates because some game related activities are available for only a limited time in the game and when the activity is no longer available, the associated game points will become inaccessible. While MAX and HS are general for all players in the game, REST is specific for the unmotivated player. The unmotivated player receives a bonus at time t1.

While the bonus system of the earlier versions of TLSBTF was based on constant bonus values at the time of interaction (t1), we now want to describe the mathematical model that takes account of the relevant variables in the game described above. Data from real time playing in specific games is needed to set the values for the parameters α and β described in our model.

In our model we use the variables REST and HS (as illustrated in Figure 2) because they are natural limit values for any bonus system at any time and their values can be used to calculate a bonus at any particular time. The calculation of the bonus is based on calculation of two different values, one for each of the limit functions $\alpha\Delta(t_1)$ and βREST(t_1) as shown in Figure 2 above. To prevent TLSBTF from becoming a preferred strategy over ordinary game play for winning the game, the awarded bonus to the passive/unmotivated player P_u will be the minimum value of these candidates (bonus1, bonus2).

At time t1 when TLSBTF is activated, the unmotivated player P_u receives a bonus. An alternative to a constant bonus system is to take into account the actual scores in the game at that time. To do this we use a ratio model based on the score of the unmotivated player constrained by the two different limit values of these variables at time t1.

First, we consider the high score variable HS. At the time of interaction between the two players, the score of the unmotivated player is P_U(t1) and the high score at this time is HS(t1). The bonus must then be a percentage of the distance, Δ, between these values but not higher. If the bonus is higher, the unmotivated player will move to the top of the high score list, which will demotivate the other players. To prevent this situation, the first candidate for the bonus, bonus1, should be a fractional part of this distance decided by α, hence bonus1 will be:

$$\Delta = HS(t1) - P_U(t1)$$
$$\text{bonus1} = \alpha\,(\Delta), \text{ where } \alpha \text{ is a positive number less than 1.}$$

HS(t1) is used as a limit value in our calculation of the bonus, where the scale line $P_U(t1)$ to HS(t1) is the relevant quantity for the calculation of the bonus.

Next we need to consider the other limit function; the rest score function bonus2. This function gives information about the available game points for the unmotivated player, REST (see Figure 2), in the game at any time. The reason we consider this value is to prevent that TLSBTF becomes a winning strategy above ordinary game play. The logic for this function is similar to the one for the high score function. At time t1, the passive player has score $P_U(t1)$ and the rest score available in game for this player is REST(t1). If the player is awarded a bonus higher than this, TLSBTF would be a winning strategy before ordinary game play, which is an unwanted result. Instead the bonus2 for this limit value is calculated as follow:

$$\text{bonus2} = \beta\ REST(t1), \text{ where } \beta \text{ is a positive number less than 1.}$$

To ensure that the bonus received by the unmotivated player is lower than both of the limit values, the final value used is the minimal value of the two values we have calculated above. That is, the bonus awarded to P_u is given by:

$$\text{Bonus} = MIN(\text{bonus1}, \text{bonus2})$$
$$\text{Bonus} = MIN(\alpha\,(\Delta), \beta\ REST(t1))$$

The new score of the unmotivated player after the interaction is then:

$$P_U(t1) = P_U(t1) + MIN(\alpha\,(\Delta), \beta\ REST(t1))$$

The values of α and β must be decided for each specific game where this dynamic bonus system is implemented.

5. Conclusion and future work

The main contribution of this paper is the refinement of The-Last-Shall-Be-The-First method from a static model, initially implemented for one specific game, into a dynamic model that can be implemented and used in most, if not all types of long-lasting pervasive games. This paper has described the model, the challenges, and how to use variables common in all long-lasting pervasive games to construct mathematical formulas for calculating TLSBTF scores in run-time. As a result, we have a dynamic model that can be explored in further research and development of the TLSBTF method, as well as research on the effect of the individual parameters on player participation. Scoring functions based on this model are easy to implement and can be developed further in other long-lasting pervasive games.

We have identified some problems when using group competition and TLSBTF simultaneously in a long lasting pervasive game to increase player participation and have suggested some solutions, but this area needs further work, especially on how to implement TLSBTF and generate the bonus list without causing the group competition to have negative effect on TLSBTF or the opposite. These problems need to be addressed in future research and development of the TLSBTF method.

References

BEAST, W. T. 2020. *The Beast (game)* [Online]. Wikipedia: Wikipedia. Available: https://en.wikipedia.org/wiki/The_Beast_(game) [Accessed February 3th, 2020 2020].
CSIKSZENTMIHALYI, M. 1990. *Flow: The Psychology of Optimal Experience*, New York: Harper Perennial.

GAMAGE, V. & ENNIS, C. 2018. Examining the effects of a virtual character on learning and engagement in serious games. *Proceedings of the 11th Annual International Conference on Motion, Interaction, and Games.* Limassol, Cyprus: Association for Computing Machinery.

HOOKHAM, G. & NESBITT, K. 2019. A Systematic Review of the Definition and Measurement of Engagement in Serious Games. *Proceedings of the Australasian Computer Science Week Multiconference.* Sydney, NSW, Australia: Association for Computing Machinery.

JEGERS, K. 2007. Pervasive game flow: understanding player enjoyment in pervasive gaming. *Comput. Entertain.,* 5**,** 9.

JEGERS, K. 2009. Elaborating eight elements of fun: Supporting design of pervasive player enjoyment. *Comput. Entertain.,* 7**,** 1-22.

MONTOLA, M. 2005. Exploring the Edge of the Magic Circle: Defining Pervasive Games. *DAC 2005 Conference.* IT University of Copenhagen, Denmark.

MONTOLA, M., STENROS, J. & WAERN, A. 2009. *Pervasive Games: Theory and Design - Experiences on the Boundary Between Life and Play*, Morgan Kaufmann Publishers.

NIEUWDORP, E. 2007. The pervasive discourse: an analysis. *Comput. Entertain.,* 5**,** 13.

PLØHN, T. 2013. Nuclear Mayhem - A pervasive game Designed to Support Learning. *Proceedings of the 7th European Conference on Games Based Learning (ECGBL 2013).* Porto, Portugal.

PLØHN, T. & AALBERG, T. 2013. HiNTHunt – A Pervasive Game to Support and Encourage Desired Activities for New Students. *In:* MA, M., OLIVEIRA, M., PETERSEN, S. & HAUGE, J. (eds.) *Serious Games Development and Applications.* Springer Berlin Heidelberg.

PLØHN, T. & AALBERG, T. Increasing Player Participation in Pervasive Educational Games. Proceedings of the 8th European Conference on Games Based Learning (ECGBL 2014), 2014 Berlin, Germany.

PLØHN, T., LOUCHART, S. & AALBERG, T. Nuclear Mayhem – Learning and Dynamic Pervasive Storytelling. Proceedings of the 8th European Conference on Games Based Learning (ECGBL 2014), 2014 Berlin, Germany.

SCHNEIDER, J. & KORTUEM, G. 2001. How to Host a Pervasive Game - Supporting Face-to-Face Interactions in Live-Action Roleplaying. *Interactions in Live-Action Roleplaying. UbiComp workshop on Designing Ubiquitous Computing Games.*

SWEETSER, P. & WYETH, P. 2005. GameFlow: a model for evaluating player enjoyment in games. *Comput. Entertain.,* 3**,** 3-3.