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**Original citation:**
Clarke, S; Lameras, P. and Arnab, S. (2016) SimAULA: Creating Higher-Level Gamification Through Adoption of a Learning-Objective to Game-Objective Mapping Approach *Proceedings of the 10th European Conference on Games Based Learning, ECGBL 2016,* 127-134. ISBN 9781911218098

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# SimAULA: Creating Higher-Level Gamification Through Adoption of a Learning-Objective to Game-Objective Mapping Approach.

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**Abstract:** In order to support the development and implementation of higher-level gamification in e-learning towards encouraging and sustaining player motivation and engagement, the authors present an analysis of the design and development approach to creating SimAULA; a gamified simulation for training teachers in using Inquiry-based learning (IBL) theory and practice. This study seeks to transfer an understanding of the design and creation methods of utilising a learning-objective to game-objective mapping process in which pedagogic theories are transformed into game objectives and challenges to create interesting learning experiences for players. A prototype version of SimAULA is presented alongside the method taken that informed the development considerations and choices whilst mapping pedagogic theory and learning outcomes of IBL practice to SimAULA's design style, delivery, game mechanics and game-play features. The paper further highlights key game mechanics that have been chosen to align with the learning-objective to game-objective mapping (LO-GO) approach, in which player choice, player ownership and learning feedback play vital roles in developing higher-level gamification methods. The authors present a case for adopting a higher-level gamification approach for advancing serious games, simulations and applications through development of player choice & ownership, narrative, feedback and game metrics to create enhanced e-learning solutions. Furthermore, the design and development methodology adopted for SimAULA is transcribed to inform the LO-GO mapping approach which is presented as a recommendation to inform future research and developments of higher-level gamification approaches for e-learning.

**Keywords:** Gamification, simulation, game objectives, learning objectives, science education, gamified design, game-based learning.

## 1. Introduction

Educational games often adopt a constructivist philosophy (Dewey, 1899; Piaget, 1970) that promotes student-led learning through the engagement of social and interactive experiences. For this reason, educational games that are well designed; that have clear learning objectives and engaging game-play, are believed by many (Karsan and Kruse, 2011; McGonigal, 2011; Zichermann and Cunningham, 2011; Kapp, 2012) to have the capacity to motivate, engage and inspire learners. The adoption of game-based-learning in training in educational applications has since seen a gradual increase in the application of gamification techniques over the last five years (Kapp, 2012). Gamification is a term used to describe the adoption of game-like mechanics, thinking and design to non-game contexts (Deterding et al., 2011).

The use of gamification in non-game contexts has frequently inspired many debates surrounding its definition (Zichermann and Cunningham, 2011), and more importantly the question, what makes gamification meaningful? (Nicholson, 2012) Critics of gamification have emphasised that the most prominent application of gamification in non-game contexts is the adoption of a games scoring system, which is considered by Nicholson (2012) to be the least interesting aspect of games. The 'standard' of gamification has traditionally seen the implementation of points, badges and leader boards (PBL) to gamify formal education applications. However, Reid (2011) argues that this approach only replicates an outdated grading system that focuses the learner on passing an examination rather than encouraging intrinsic motivation and development of a learners understanding. Whilst this approach to gamification is still widely adopted, proponents of higher-level gamification; narrative, challenge, meaningful choice and creative exploration, are voicing the need to move away from the PBL 'standard' to explore the intrinsic values that games can offer.

Building on work conducted by Arnab et al (2015) in the mapping of learning mechanics to game mechanics, the authors present an approach to creating meaningful higher-level gamification, that maps individual learning objectives to individual game-based objectives such as quests or target driven goals. Through the mapping of individual learning objectives to tangible game-like goals it is possible for a learner to have a greater understanding and control of what they are learning, alongside the potential exposure to instant feedback once they have or have not accomplished a goal within an application. Within this paper, the authors present an example of a learning objective to game objective mapping approach (LO-GO) that was developed for SimAULA, an educational simulation for teacher training, in which an overview is presented in Section 3. The pedagogic design process that was adopted to inform the learning objectives is presented in Section 4 and the development approach of the game-based goals that were needed to reflect the learning objectives are further explored in Section 5. Future work and conclusions are reviewed to reflect the overall process of developing meaningful, higher-level gamification through the adoption of learning objective to game objective mapping.

## 2. Background

The term "Gamification" has developed in recent years from a vested interest of adopting game-like concepts, applications and mechanics to non-game contexts more and more frequently (Deterding et al., 2011). According to Werbach & Hunter (2012) the term "Gamification" was first coined in 2003 by Nick Peller, a British game developer who developed game interfaces for non-game environments. However, the general concept of adopting game-like functions for academic purposes has been around for far longer (Morford et al., 2014) with Coleman (1971) proposing the benefits of games and play in educational settings in the 70s. Gamification has since become in its own right the fashion of our time on the business and marketing scene (Kumar, 2013), and has been promoted as one of the optimal methods in delivering educational reform and behavioural change through the use of game-like behaviours such as; challenge, achievement and reward. The adoption of the gamification trend has been so successful in digital marketing that a report developed by M2 Research (2012) predicts that by 2016, the gamification market will be worth over 2.8 billion dollars.

Although the term "Gamification" is a widely known and accepted practice, its meaning is often disputed, especially in the games community (Deterding et al., 2011). The term gamification has been used to describe a number of different applications and as such the meaning varies from person to person (Zichermann and Cunningham, 2011). However, it is not just the term that produces criticism of gamification but also the way in which it is applied to non-game contexts. Over-application of 'easy' game-based functions such as scoring systems that include points, badges and leader boards (PBL), have led critics to question whether player motivation and engagement is gained through use of these simple systems or whether it is a marketing ploy to jump on the gamification trend. Robertson (2010) suggests that the use of PBL as a way of gamification is "taking *the thing that is least essential to games* and representing it as the core of the experience". Whilst PBL are certainly important functions of games as a way of communicating to a player their progress and status throughout play, the functionality of PBL, does not contribute to the core make-up of games that rely on development of player challenge, curiosity, meaningful choice and emotional connection to motivate and engage a player. As such, Roberson (2012) believes that the use of scoring mechanics as a way of gamification does not create meaningful results in learner engagement or motivation, and adds nothing more than a points system to a non-game activity. Other critics have gone so far to say that the use of PBL is a form of exploitation which is "primarily the practise of marketers and consultants to exploit an opportunity for benefit" (Walz and Deterding, 2015). Following the idea that gamification is just a new tactic of exploiting money from businesses, Bogost (2011) an open critic of the use of gamification as exploitation, expressed his distaste at ill-use of the medium of games for business purposes:

> *"The rhetorical power of the word "gamification" is enormous, and it does precisely what bullshitters want: it takes games -- a mysterious, magical, powerful medium that has captured the attention of millions of people -- and it makes them accessible in the context of contemporary business." Bogost, 2011.*

The marketer's easy use of gamification as Bogost (2012) suggests does little more than look to capitalise on the expanding gaming culture trend as quickly and efficiently as possible with little after thought to the real needs of the player. Maroney (2001) sums up the application of marketer PBL led practise by emphasising that a points-based system focuses solely on the goals of a game but leaves the playful element of a game behind.

To move forward from this view of exploitation and create 'meaningful gamification' (Nicholson, 2012) in order to support educational ventures, learning professionals must look to utilise the interesting features of games such as curiosity, challenge or narrative to increase their learner's performance (Kapp, 2012). In order to do this, we must consider player fun and engagement to be the central goal in creating higher-level gamification and utilise game mechanics and techniques that reflect this purpose. The player should form the central theme in which meaningful gamification should grow, with the player motivation ultimately driving the outcome of the gamification (Zichermann and Cunningham, 2011). Nicholson (2012) summarises this view by proposing that meaningful gamification should stem from the needs of the player rather than the needs of the organisation. Following Nicholson's (2012) theory of developing 'meaningful gamification' through the creation of meaningful game experience, SimAULA was designed to include a series of game mechanics and systems that actively encourage player curiosity through challenging game-based objectives presented via a non-linear dialogue system that is more responsive in terms of player role development and simulation narrative. Adopting this approach, the authors attempt to create a basis for higher-level gamification through the development of learning objective to game objective direct mapping.

Presented in the next section is an overview of the gamified simulation; SimAULA, a training platform created for the purpose of developing teacher confidence in delivery, planning and communication skills in Inquiry-Based Learning in STEM education. SimAULA was used as a test case to develop the application of a learning objective to game objective mapping approach and is used to further explore whether this technique has a place for achieving higher-level gamification.

## 3. SimAULA: A Gamified Training Simulation

The current teaching paradigm in STEM education is centred on the promotion of student-led learning through scientific experience. Following this shift, the application of Inquiry-based learning (IBL) has become more and more popular as a teaching method in the classroom environment (Hall, 2002). IBL is a branch of experience learning that is designed to bring focus to a student-centred developmental approach that applies the use of active learning strategies such as student-led research and inquiry, peer instruction and discussion, team-based learning and self-reflection (Smith et al., 2009; Knight and Wood, 2005).

In order to support the adoption and implementation of Inquiry-Based Learning (IBL) in STEM education, the authors were tasked with developing a gamified approach to facilitator training for IBL strategies and best practices. In response to this task, a gamified training simulation titled SimAula was developed, which draws focus on presenting and training facilitators in the 5 primary areas of IBL practise; Orienting & Asking Questions, Hypothesis Generation & Design, Planning & Investigation, Analysis & Interpretation and Evaluation & Conclusion. In using SimAULA, the player may practise their delivery and communication skills in relaying open-ended questions and tasks associated with IBL practise in a learner directed manner in order to support their development and experience of using IBL in a classroom like environment.


**Figure 1** SimAULA: IBL Training Simulation

## 4. Pedagogic Design and Learning Objective Development

The National Research Council (NRC) Features of Inquiry, was developed by the National Science Education Standards (Loucks-Horsley, S. & Olson, S. eds., 2000), (Table 1), and was considered an essential resource for designing SimAULA's pedagogical model. Therefore, the NRC's Features of Inquiry were adapted to match the distinct characteristics of a game-based learning approach encompassing the game mechanics and game play of SimAULA. The adjustments entailed some structural considerations as well as the addition of 'Reflection' as a further essential feature. This is consistent with widespread recognition of the importance of student reflection activity in many recent conceptualizations.

**Table 1:** NRC Features of Inquiry and their variations (Loucks-Horsley, S. and Olson, S., 2000.)

| Essential Features | More / Less | Amount of Learner Self-Direction / Amount of Direction from Teacher or Material | | Less / More |
|---|---|---|---|---|
| | Variations | | | |
| Learner engages in scientifically oriented questions | Learner poses a question | Learner selects among questions, poses new questions | Learner sharpens or clarifies question provided by teacher, materials or other source | Learner engages in question provided by teacher, materials, or other source |
| Learner gives priority to evidence in responding to questions. | Learner determines what constitutes evidence and collects it. | Learner directed to collect certain data | Learner given data and asked to analyse | Learner given data and told how to analyse |
| Learner formulates explanations from evidence | Learner formulates explanation after summarizing evidence | Learner guided in process of formulating explanations from evidence | Learner given possible ways to use evidence to formulate explanation | Learner provided with evidence |
| Learner connects explanations to scientific knowledge | Learner independently examines other resources and forms the links to explanations | Learner directed towards area and sources of scientific knowledge | Learner given possible connections | Learner given all connections |
| Learner communicates and justifies explanations | Learners forms reasonable and logical argument to communicate explanations | Learner coached in development of communication | Learner provided with broad guidelines to use to sharpen communication | Learner given steps and procedures for communication. |

The Inquiry model is perceived as a cyclical path of the inquiry process where inquiry starts with posing questions and ends with reflection. Each step in the process leads to the next, generating new questions, constituting evidence, analysing evidence, formulating explanations, connecting explanations, communicating findings and reflecting on the inquiry process. These overarching features of inquiry-based learning are integrated into the Simulation's core design and when selected, associated inquiry activities are evoked based on the feature selected. A student-teacher can then explore each of the phases that are considered core IBL practice, to ensure that they are developing their skills in a safe and contained environment.

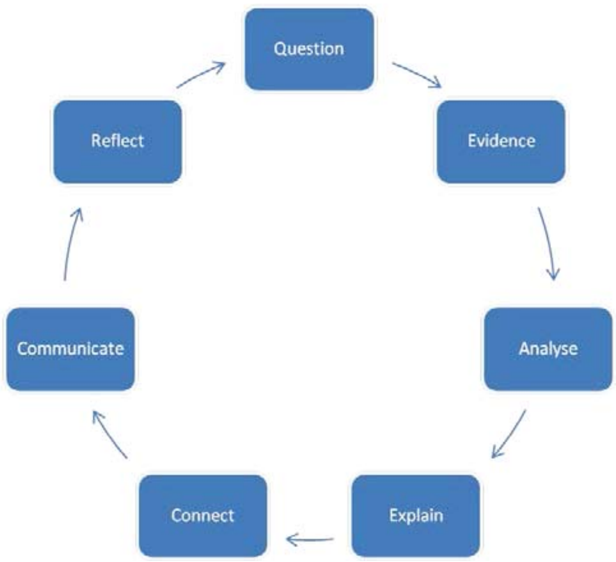


**Figure 1:** The SimAULA 7-step inquiry model

The model is mapped to SimAULA's pedagogical design in order to plan and create associated inquiry-based learning activities that place inquiry as a central feature. To achieve this, the authors mapped essential features of inquiry (Table 1) to the SimAULA Inquiry Model (Figure 2) for describing inquiry-based activities that are performed in the game.

**Table 2:** Mapping NRC inquiry features to inquiry features and inquiry activities in the SimAULA game.

| Inquiry Features from NRC | Inquiry Features in simAULA | Description of Inquiry Activities in simAULA including student & teacher roles |
|---|---|---|
| Learner engages in scientifically oriented questions | Questions | Students (avatars) are provided with a scientific topic which are presented as an embedded video in the simulation. Students are jotting down their questions and they are starting to pose them to the rest of the classroom. The teacher(user) provide guidelines on how questions should be formulated and also clarifies, refines the questions posed by students through the in-game top-down menu. |
| Learner gives priority to evidence | Evidence | Students (controlled by the simulation) are starting to create hypothesis for a scientific phenomenon by using the in-game scientific tools (e.g. scientific microscope, or virtual experiment) for data collection. The teacher elaborates/refines the steps for hypothesis generation, testing and evaluation through the in-game prompts. |
| Learner formulates explanations from evidence | Analyse | Students proceed to analysing data collected based on processes of analysis suggested by the teacher within the simulation and available to the student via the GUI. The teacher suggests a number of data analysis methods and guides the whole process of analysis. |
| Learner connects explanations to scientific knowledge | Explain & Connect | After conducting the analysis, students are explaining, comparing and connecting data with prior evidence. Teacher suggests through the top-down in-game option how to start the process and also recommends resources such as books, journals, Web that include relevant studies for students to explore. |
| Learner communicates and justifies explanations | Communicate | Student forms logical arguments to communicate findings in a way that it can be understood from the wider scientific community. The teacher monitors the process and gives guidelines and clarifies/corrects arguments when appropriate through the in-game dialogue options. |
| - | Reflect | Student reflect on the scientific investigation and on the inquiry process based on guidelines provided by teacher through the in-game top-down menu. |

For example, activities that focus on the player posing Questions include certain processes that involve NPC students. Players can choose from several scientifically-oriented questions in order to explore the 'Questioning' phase of the simulation. During the Evidence phase, NPC students replicate a series of scientific hypothesis, such as the Eratosthenes experiment, by using the in-game scientific tools (e.g. experiments) for data collection. The player can choose how to provide guidelines and clarification through the in-game prompts to work through and explore these hypotheses as they would in a real classroom environment. In the Analysis phase, NPC students undertake data analysis by using research methods and processes suggested by the player. In Explain & Connect, the NPC students compare and connect data to prior evidence. The player then has several opportunities to suggest through the top-down in-game options, additional educational content that could be utilised such as books, journals and resources from the Web. During the Communicate phase, NPC students communicate findings through logical arguments in conjunction with the teacher's suggestions and prompts that are selected by the player when appropriate. Finally, in the Reflect phase, NPC students 'reflect' on the scientific investigation and on the inquiry process based on the assistance and support provided by the player and selected via the dialogical menu in the game. For orchestrating the inquiry activities there is no specified sequence, therefore the activities could be repeated based on the number of times that is necessary to complete a learning outcome. We perceive that the activity of mapping or classifying learning objectives to game objectives is an essential process when designing serious games, as this informs the mechanisms for transforming learning to tangible game principles in which the players are set clear game and learning goals.

## 5. Game Objective Mapping

To develop the theory of learning objective to game objective direct mapping, learning objectives were first developed to coincide with the five primary stages of IBL; Orienting & Asking Questions, Hypothesis Generation & Design, Planning & Investigation, Analysis & Interpretation and Evaluation & Conclusion in the design phase of SimAULA. Each of the IBL primary stages and the learning objectives assigned to each stage were split to form levels within SimAULA. Each primary stage of IBL related to one game level with five levels in total being developed for SimAULA. Further information regarding the development of the learning objectives can be found in Section 4: Pedagogic Design.

Once the learning objectives had been developed for each primary stage, the developers formulated game like objectives that would map and reflect the learning objectives that a player would need to complete in order to progress in the game and show that they were effectively learning. Game objectives were designed to build up the players understanding of IBL practise by asking them to achieve an objective. Once the objective had been completed the player would be asked to repeat that same objective a series of times as a new game objective. Using sequence repetition, the luck element of having a player randomly selecting the right answer is diminished and greater emphasis is placed on player proficiency and understanding of the educational message in order to progress through the simulation. The game objectives observed in Table 3 presents an example of the learning objective to game objective mapping that was developed for Level 1: Orientating & Asking Questions, of the SimAULA platform. As shown, the learning objective to game objective mapping for Level 1 presents a gradual learning curve in game mastery and achievement complexity that is challenging yet rewarding to the player. The game learning curve reflects the desired learning curve of a player's expertise and proficiency in IBL practise that is developed gradually through use of SimAULA, supporting the player from novice to master in both instances.

**Table 3:** SimAula: Level 1 Learning-Objective to Game-Objective Mapping

| | Learning Objective | Game Objective |
|---|---|---|
| **1.** | To understand how an inquiry question is being posed to students | ▪ Ask one Inquiry Based Question<br>▪ Ask three Inquiry Based Questions in a row |
| **2.** | To understand how to guide students in forming their own questions | ▪ Get five 'Great' ratings in a row<br>▪ Get all students into an inquiring state |
| **3.** | To become aware of how an inquiry question / and subsequent follow-up questions and probes lead to a classroom discussion | ▪ Start 3 classroom discussions through choosing IBL questions |

Utilising a learning objective to game objective direct mapping approach in the development of SimAULA allowed the developers to plan and support a purposeful game flow alongside a specified educational function, through meaningful tracking of what the player should be learning with the achievement of in-game objectives. Alongside this benefit to the functional side of development and evaluation of a gamified simulation, it provides a player with clear game-based goals that offer fun, challenge and engagement but also provide a higher educational purpose in which clear learning objectives through the achievement of each of the game objectives is presented to the player. To ensure that the learning objective to game objective direct mapping approach was not received by the player as a detached and scientific method of learning, a non-linear dialogue system was developed in which the objectives were imbedded. This mechanic was used to encourage a natural feeling of a classroom simulation in which the player could experiment with communication and develop a sense of meaningful impact and investment through the ability to choose their own path through SimAULA.

A non-linear dialogue system is traditionally used in entertainment games to allow the player to choose how their character reacts to situations and other characters within the game environment (Bateman, 2006). This allows the player a greater sense of freedom and control over their play experience within a game and leads to player consideration of meaningful choice through their in-game actions. In SimAULA, the player adopts a teacher role within the simulation in which they deliver various science related topics to a selection of NPC students. The use of non-linear dialogues in SimAULA allows the players to cast themselves in the teacher role and direct how they would deliver the chosen lesson materials. Through this system, the player learns to communicate and develop their delivery skills using IBL practises. Following the role-play, feedback is given via a response to a player's chosen option within the dialogue system. The responses are then presented to the player through a number of feedback mechanisms to indicate to the player whether the option they chose was in-line with IBL practise. Using this system, the player is encouraged to think carefully about how they are communicating to the NPC students and are encouraged to employ open-ended options for posing questions and relaying information and feedback that promote best-practise in IBL delivery.

To manage a non-linear dialogue system within SimAULA, the developers utilised ChatMapper to help support the dialogue creation process. ChatMapper is a software tool for specifically developing dialogue structures and narratives for games, TV, theatre etc. ChatMapper was utilised in the development phase of SimAULA to support the dialogue authoring process in terms of designing, editing and organisation before final integration into the program. The tool was used to structure game objectives in accordance with the learning objectives into the dialogue system and was used to help track player and NPC related dialogue in a consistent and organised manner. Through the application of ChatMapper, the developers were able to manage both the learning objectives and the game objectives through the development of the dialogue. An additional benefit of applying the learning objectives to game objectives direct mapping approach is that it supports the use of game metrics to gather data on objective completion rates to support the simulations evaluation phase. The use of metrics in educational games or simulations allows specific game objectives through metrics data to be tracked and analysed. Data can be collected on issues of play within the simulation such as; players did not complete areas or found questions problematic. This data allows the developers to assess the overall simulation and make any needed changes to support the users. The use of metrics data with learning objective to game objective mapping also supports facilitators to identify areas that learners may need further support in which tailored feedback to the related area of IBL training may be required.

The development process of learning objective to game objective mapping in the case of SimAULA has provided a valuable first insight into creating higher-level gamification in learning simulations and games. Shown below in Figure 4 are the development considerations taken in SimAULA, which have been presented throughout Sections 4 & 5 in order to create a more meaningful gamification method for engaging players through learning. The development considerations presented in these sections have been used to form a LO-GO mapping approach which highlights some of the core development processes taken in the case of SimAULA. Considerations of this development strategy were further informed from Arnab & Clarke's (2015) Trans-disciplinary Model in which learning objectives are defined and then worked to inform the design and development of mechanics for creating serious games. Further development and evaluation using a LO-GO mapping approach is proposed for validation of this method in developing higher-level gamification in simulations and game-based learning applications.

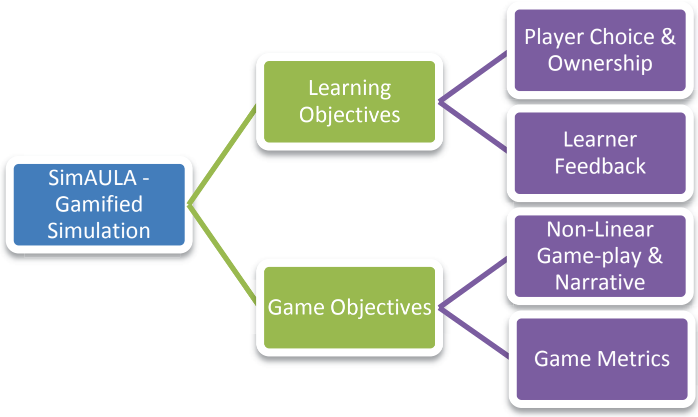


**Figure 3:** LO-GO Mapping Approach

## 6. Conclusions

Game-based learning is often designed without rigorous considerations on the mapping of potential game mechanics to the mechanics and dynamics of a learning process. A design process usually does not need to be formulaic. However, if relevant learning metrics and the means to achieve the metrics i.e. mechanics are to be embedded in gameplay, it is essential that the process by which game mechanics and rules are selected takes these learning elements and constructs into account. Creating a learning-objective to game-objective mechanics mapping approach, this paper has discussed a platform for facilitating meaningful higher-level gamification by mapping individual learning objectives to relevant game-based objectives. The mapping of learning objectives to game-like goals allows a learner to have an effective play-learning experience. Informed by the design and development considerations of the SimAULA game, the LO-GO mapping approach highlights the engagement relationship between learning objectives and game objectives to support the use of player choice and game metrics to gather data on objective completion rates, which facilitates the evaluation phase of a play-learn session. The use of metrics in educational games or simulations allows specific game objectives through metrics data to be tracked and analysed. Future work will include further expansion of the LO-GO mapping approach alongside user engagement and usability trials that obtain user data to observe factors such as player engagement, enjoyment and efficacy of the proposed higher-level gamification techniques applied in SimAULA.

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