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Game Based Learning for Seafarers. A Framework for Instructional Game Design for Safety in Marine Navigation

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ABSTRACT: Games according to Gee (2003), are 'multimodal texts' belonging to distinct 'semiotic domains' that employ a range of strategies in which images, words, sounds, music, movement and bodily sensations are factors, and their recognition and production evidence of the learning of these emerging literacies. Game based learning and educational game design, is a multifactor domain combining educational psychology, learning theory and computer games research demanding the cooperation of two different scientific areas, education and computer science, having a common work "game design". In educational games, game design includes a major task, "embedding suitable educational approach and instructional techniques, for specific learning outcome and student profile, into the scenario and game play without loosing the fun and attractive part of it." In this paper a framework for designing educational games is presented and applied to maritime education for navigational safety training. The game is designed for adult seafarers and maritime faculty students in non-formal educational settings.

1 INTRODUCTION

Game Based Learning (G.B.L.) can be very a powerful educational model as part of non-formal or informal e-learning with supplementary and supportive scope to formal education.

Maritime industry can get full advantage of this emerging technology providing a new way for life long learning and distance education that supports active and critical learning.

Unfortunately GBL faces a lot of problems come partly from the vast differences in how people think and operate in both arenas: Instructional design that is connected to education part tends to be systematic, reasoned, and grounded; and gaming experience that is more likely to be idiosyncratic, intuitive, and novel.

2 MARITIME EDUCATION

Regulators and shipping interests attempt to create a safer, more environmentally friendly and secure maritime transportation sector, writing conventions such as the STCW that requires specific levels of knowledge, understanding and skill for all seafarers on each level of responsibility. Despite this they have been confronted with the fact that still human error is the main cause of shipping incidents. Human error is present in 80% to 90% of all shipping accidents. Det Norske Veritas Forum (2000), has recently concluded "human error still continues to be a serious challenge, accounting for 58% of major [insurance] claims".

If it is accepted that there is a desire to improve maritime transportation system, and that human factors represent one of the key weaknesses in the system, then there is a need to improve the

capabilities to deal with human factor issues. An attempt to answer the this question come to lifelong education and practicing and especially in shipboard training that occupies a large part of quality education.

In order to create such an educational system we must analyze learner profile, learning content, learning and performance context and support it by suitable learning theories and instructional design. That's why before proposing an educational tool such as educational games, we first have to analyze the maritime industry from education point of view.

2.1 *Characteristics of Sea Service Environment*

The sea service environment on board has special characteristics (Chung Do Nam, 2002) that must be taken into account while performing needs assessment and analyzing performance context, at the analysis and design phase of an educational tool.

1 The attitude of provision against a disaster at sea is required due to risky environment and continuous danger exposition.
2 An absent-mindedness and a trifling error from the crewmember can not be unpardonable because of the responsibilities for safety, environment protection and maintenance / management of ship and cargo property.
3 In case of an accident happens on ship, it must be treated properly without external assistance.
4 The seaman is easy to be under stress mentally and also to be tired physically due to continuous work and restrictive / isolated life.
5 Professional knowledge and skills in a high degree are required for ship management because a ship is a composition plant integrated with various techniques of different fields.
6 Seaman must follow instructions and obey orders absolutely in case of emergency.
7 The seaman must know the relevant facts well about the international law and the environment preservation since his ship calls at the international ports.

2.2 *Seaman's needs*

A talent and ability a seaman officer should have in order to perform his duty are as follows:

1 High professional knowledge and technical skills necessary for ship operation management.
2 Precaution and carefulness against potential of danger and ability of its treatment when an accident happens.
3 Collaboration and leadership abilities.
4 Neatness, arrangement and responsibility.
5 Time observance.
6 Strong mind and physical power.
7 Courtesy and education in human relationships.

2.3 *Maritime Education characteristics*

In order to train marine officers of talent and capacity required in a sea service, maritime education has characteristics as follows:

1 Completion of various courses necessary to the ship operation management like basic science, applied science, social science, and language etc…
2 Completion of courses necessary to obtain standard qualification such as various basic educations provided by the international convention.
3 Adaptation, self-restraint and leadership in a specific environment, and also cultivation of seamanship.
4 Field education through embarkation training.
5 Cultivation of treatment ability against danger in an emergency.
6 Lifelong and continuous active and critical learning.

3 GAME BASED LEARNING

The idea of using computer games for education is not just a concept inspired by educators and researchers, but is also found in leading game designers' description of the most basic incentives for playing computer games. In the words of game designer Chris Crawford (1982), "*The fundamental motivation for all game-playing is to learn*".

What is important is to consider how to integrate, and not just add, games to the educational tool set, blending them with learning activities. Integration requires an understanding of the medium and its alignment with the subject, instructional strategy, student's learning style, and intended outcomes. Integration of games into curricula is much more likely to be successful than mere game use.

3.1 *Games are not simulations*

Often, when we are talking about educational games, we think of it as a simulated environment where player can test his knowledge and skills. Simulation in maritime education is a commonly used tool and is often confused with games. In fact, simulation is a quite different learning activity than games.

The close relationship and at the same time difference, is best captured by Coleman's (1973) term simulation games that describe how simulations

become games when we apply goals to the possible activities in the simulation. Goals are tied to the conflict and necessary for the player to really invest strong feelings in the game. Even when computer games do not set up specific conflicts and goals most players will invent their own, and use the simulation to achieve these goals, making up their own game experience.

Also, in simulations, the realism of the model has high priority, whereas a computer game will often sacrifice realism if it benefits the overall game experience. Computer game is not primarily about simulating, but rather providing an interesting experience by the player fulfilling explicit goals.

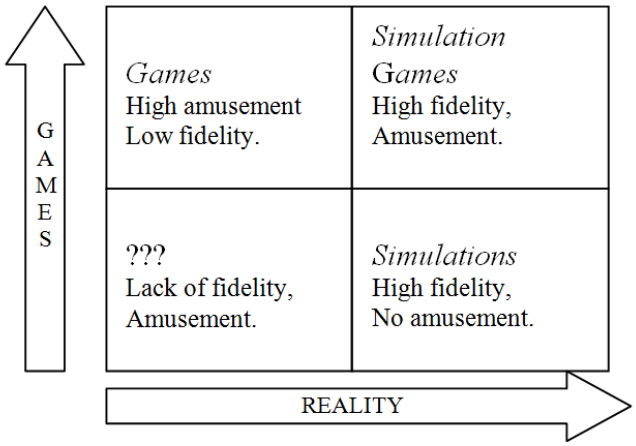

Fig. 1. Games vs simulations

Thiagarajan (1990) suggests a useful division between low fidelity and high fidelity simulations to address the difference between game and simulation.

3.2 *GBL and educational application level*

Games can support all educational application level, as STCW states, based on various game-world, structure and play supported by different genres.

At the ***event level or Lesson level***, a game may be designed to facilitate one or more specific instructional event within an instructional unit. A relatively simple game, like adventure (quiz, puzzle) or table top games for example, may be designed to present learners with a scenario engaging their interest and asking them to explore related concepts through a series of readings and activities in order to facilitate recall of factual content or to promote active involvement and discussion (Dempsey, et all 1996).

At the ***unit level***, a game incorporates all of the events and activities necessary to achieve a specified set of goals and objectives associated with an instructional lesson or unit. That means the game, like simulation games, will be designed to engage learners, facilitate exploration, solicit explanations and elaborations, and evaluate learning.

At the ***course level***, one game is played throughout an entire course, tying together all the units, lessons and events associated with the course. Business strategy simulation games are best suited this case.

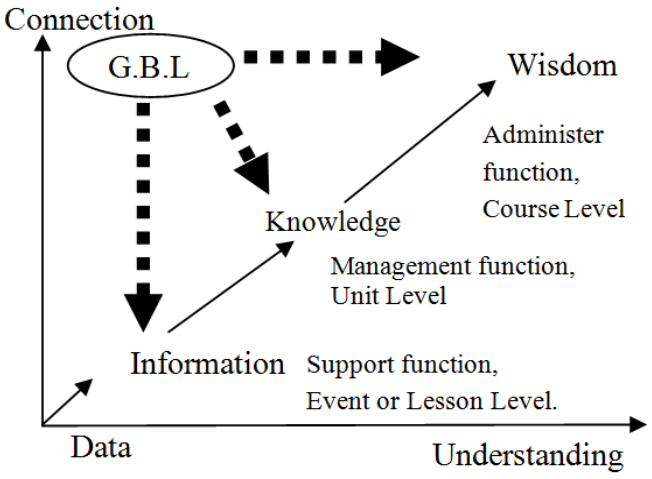

Fig. 2. GBL for all educational levels

The distinctions are important because the process and resources necessary to apply *pedagogy* (defined here as the science of teaching and learning, including both youth and adult learning), for designing and developing an instructional game may differ significantly depending on the level of application.

3.3 *Games can support all learning needs*

Similarly, game environment can support both the mundane 'acquisition of facts' through drill and practice, and the complex acquisition of process skills through simulation (Kirriemuir J. et all, 2004).

Table 1. Learning theory, object and game genre

Aspect	Behaviorist	Cognitive	Constructivism
Learning process.	Changes behavior	Process entirely in the head of the learner	Discover and transform complex information.
Purpose in education	Produce behavioral change in desired direction	Develop capacity and skills to learn better.	Explore mechanisms built the knowledge as logical sequence.
Learn what	Facts, skills, procedures.	Judgment, Reasoning.	Theories, Process
Game genre	Action, sports, role-play, adventure, tabletop.	Business simulation, adventure, strategy.	Strategy, adventure, open ended simulation.

3.4 *Teaching strategies and GBL*

Nevertheless, games can incorporate many of the referred teaching strategies. Games as instructional means are characterized by many shared teaching strategies independently form the game genre they belong to. Analyzing game genres we focus on some built in teaching strategies for each genre (Egenfeldt-Nielsen, S., 2005).

Table 2. Game genre and suitable instructional strategy

Game genre	Sub genres	Supported Teaching Strategies	Shared teaching strategies
Action games	Adventure	Pedagogical scenario, Storytelling / narratives, direct.	Group and Cooperative Learning. Motivation based learning. Problem based learning. Active Learning (Learn by Doing, Learn by mistake) Micro worlds Interactivity, prompt feedback Reinforcement Engagement theory Experiential Learning Inquire-based learning. Case studies Time on task
	Fighting	Direct instruction	
	Table top games	Direct instruction, object based learning.	
Role-playing games		Pedagogical scenario, role-playing.	
Platform games		Direct instruction	
Simulation games	Simulators	Concept mapping, simulations, object based learning, direct instruction.	
Sport games		Direct instruction.	
Strategy games	Strategy and tactical war games	Organization, project-based learning, concept mapping, thematic instruction.	
	God games	Project based learning, thematic instruction, pedagogical scenario, project based learning storytelling / narratives, role-playing,.	
	Business strategy simulation games	Pedagogical scenario, storytelling / narratives, thematic instruction, project based learning, role - playing, concept mapping, simulations.	

3.5 *Educational games' structure*

Stapleton and Hughes (2005) posit a schema that helps illustrate how the results of fundamental ID tasks on game's main conventions facilitate the design and development of instructional games.

Fig. 1. Game main conventions and ID events

Gaming main conventions

1. Story's Intentional Learning (Instruction)
   Character .. Worlds .. Events
2. Play's Incidental Learning (Practice)
   Stimulus .. Response .. Results
3. Game's Intrinsic Learning (Performance)
   Goals .. Tools .. Rules

Gaming fundamental ID tasks

1. Expose, Inquire,
2. Discover, Create,
3. Experiment, Share

4 EDUCATIONAL GAME DEVELOPMENT FRAMEWORK

In order to produce educational computer games beyond edutainment we must combine commercial game developers – designers and instructional designers / educators subject matter experts (Hirumi, A. 2002). These two parts can be mediated if we apply a suitable instructional strategy during game design. The goal of an Instructional Strategy is to incorporate education into games. The instructional strategy proposed here is based on the instructional design of Dick and Carey (2001) "Systems Approach Model for Designing Instruction".

4.1 *Analysis phase (What the game is about)*

Table 3. Description of Analysis Phase

Tasks	Educators / Instructional designers	Game Designers / Developers
Define learning goals, skills and knowledge.	Assess needs, education scope. Reconcile formal education lesson plans. Decide prerequisites and learning outcome level. Identify suitable learning theory.	Combine learning goals with entertainment goals. Identify game complexity and genre.
Create learners' profile	Make Learner analysis (Entry behaviors, needs, learning method, attitudes demographics, game experience).	Identify game difficulty, levels, challenges, availability and interface.
Learning context and scope	Instructional design, assessments, educational and instructional resources.	Decide hardware requirements, resources, networking
Performance context	Game world settings and learning activities. Check the analogies between reality and imaginary game world. Draft IMS-LD document.	User interface, game genre. Make a draft game story. System dynamic tools may be used.
Basic instructional approach	Design structure	Game genre, game play. Decide game design approach method.

Analysis phase results.

Concept document includes short descriptions of:

1 The Premise or High Concept (what makes the game exciting and sets it apart from other games),
2 Player Motivation (game's victor condition),
3 Game Play (what player will do while playing)
4 Story (main events, characters, and settings),
5 Target Audience/Market,
6 Game Genre,
7 Target Platform, Hardware Requirements,
8 Game Goals.

4.2 *Design phase (Fleshing out the details)*

Table 4. Description of Design Phase

Tasks	Educators / Instructional designers	Game Designers / Developers
Game play	Generate objectives. Associate learning activities with learning objects and objectives.	Game play (players' actions, strategies, motives and game's reactions. User Controls)
Game rules.	Factor analysis and system dynamics on player activities and game world events.	Game structure (the rules of the game applied to players and simulated environment. Artificial Intelligence.)
Game world, competition.	Cluster and sequence the objectives. Communicate the organization of objectives to developers. Create the IMS-LD document.	Define game levels by considering game and instructional flow, duration, availability, relationships and difficulty. Define the overall story. User interface.
Delineate Learner Assessment Methods	Assess What: Concrete entertainment goals and objectives Assess When: Before game starts, At the beginning of each level, during or at the end of each level, after the game. Assess Where and how: Integrated within the game, Conventional criterion referenced testing methods or product and performance checklists.	Determine learner assessment and ensure alignment between objectives and assessments. Decide game rewards and penalties as assessments' results.
Apply Grounded Strategies and Events	Identify instructional events associated with the instructional approach or strategy selected during concept development. Verify that grounded instructional strategies and events are embedded within the artistic story and game play.	Integrate grounded instructional strategies and events with story events to optimize GBL exploiting similarities and resolving differences in story and instruction. Integrate one or more grounded events to facilitate the achievement of terminal objective.
Begin Formative Evaluations	Expert reviews by subject matter experts as well as media, learning and human factors specialists One-to-one evaluations identify and remove the most obvious errors in the instruction and to obtain initial reactions to the content from learners.	

Revision	Identify difficulties experienced by learners in achieving objectives and relate these difficulties to specific deficiencies in the instruction. Re-examine the validity of the instructional analysis and the assumptions about the entry behaviors and characteristics of learners. Review the instructional strategy.	Verify game difficulty suits to specific players. Check the consistency of game story and the integration of game objectives. Ensure game controls and user interface are simple and easy of use. Make sure players knows what to do at each level – part of the game. Examine if player is motivated, if assessments does not break game flow and if game is attractive and pleasant.

Design Phase Results

1 IMS – LD document. IMS Learning Design focuses on the organization of learning activities. Modern pedagogical theory insists on the importance of scenarios, i.e. story-boards that define learning activities. The IMS Learning Design Specification (IMS-LD) provides a very thorough framework for evaluating the capabilities of software tools within the learning design space and also a platform-independent notational convention to allow sharing and re-use of these designs

2 Game design documents (GDD), it is an extension of the concept document, a project overview and detail descriptions of: Game world, Game play, Game structure, Art, Audio and Technical Features, Production Details

3 The Art Bible establishes the look and feel of the game and provides a reference for other art. It helps ensure consistency in style throughout the game and typically consists of:

- A set of visuals (ranging from pencil sketches to digitised images that capture final look of the game); and
- A visual reference library that reflects the direction the art should take over time.

4 The Technical Design Document is based on the GDD and includes a description of:

- The game engine, including comparisons with other engines on the market;
- How game will transition from concept to software;
- Who will be involved in the development of the game engine, including what tasks each person will perform, and how long it will take to perform each task;
- What core tools needed to build the game; including hardware and software that must be purchased.

5 Game prototypes.

4.3 *Production Phase*

Table 1. Description of Production Phase

Tasks	Educators / Instructional designers	Game Designers / Developers
Complete Formative Evaluations	Small group evaluations are to determine the effectiveness of changes made following the one-to-one evaluation. Field trials are recommended for the Beta version of instructional games. The primary purposes at this stage of production are to complete testing, fix all bugs, fine tune performance, and ensure the game may be used in its intended setting.	Game developers create and test prototypes, during design phase, and various versions of games during production. Such tests tend to focus on ease of use, documenting and fixing programming bugs, and ensuring the game is (still) fun to play.

Production Phase results

For the Alpha version, the game is playable from start to finish, but there may be few gaps and the art assets may not be final. Game engine and user interface are both complete. Production of the Beta version focuses on fixing bugs and the integration of all assets. The objectives are to complete testing (including use on all supported platforms), bug fixing and performance tuning. For the Gold version the product has been reviewed and finalized and is ready for production.

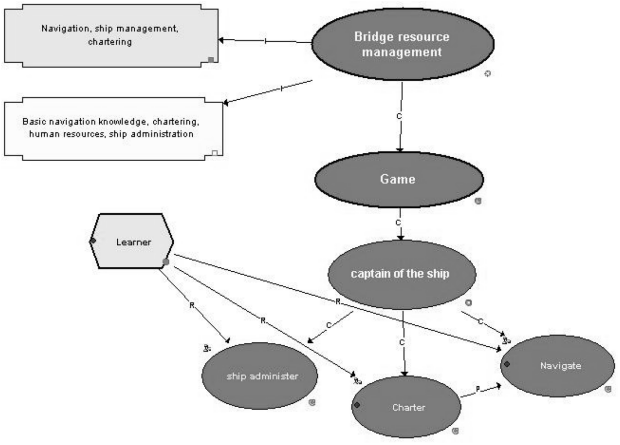

Fig. 4. General IMS-LD objects

5 GAME PROPOSAL "THE CAPTAIN"

An educational game for maritime industry is under development according to the above framework. Analysis phase has completed and results are presented at the following brief concept document.

Table 6. Concept document

The Premise or High Concept	An educational game with embedded instructional design and assessments that will still be fun to play. An interesting and intriguing game story and game play for the target audience.
Player Motivation	Increase your earnings, and gain the reputation of best captain.
Game Play	Navigation, travel cost estimation, crew administration and commercial management of a cargo ship.
Story	You are the captain of a merchant ship. Find a cargo contract suitable for your ship, make a contract, get to the port where you will load the cargo at specific date/time, deliver it to the destination port, and then you get paid according to the contract. Take care of your ship; buy food supplies, petrol, deck supplies and take care of your crew. A lot of incidents may arise during your travel, like crew diseases, navigation faults, port strikes, port traffic, bad weather, engineering problems, ship damages and much more. You can predict and overcome most of these problems if you take right decisions and act consequently. Competitor captains do their best too.
Target Audience / Market	Seamen and maritime students of merchant maritime industry.
Game Genre.	First person, business strategy, real time simulation game.
Target Platform, Hardware	Windows platform, standalone pc with high quality graphics card, 512 MB RAM and 17'' monitor.
Game goals.	The purpose of the game is to become the best captain since your career is just beginning. Navigate, charter and administer your crew better than competitors.

The second phase is in progress. Some results are presented according to the IMS – LD document.

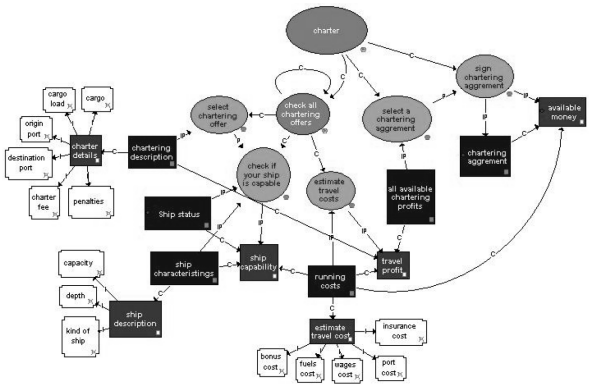

Fig. 5. Chartering concepts, Facts, Principe and Procedures

6 CONCLUSION

Educational Games is a promising emerging technology suitable for educational needs of maritime industry. GBL can be applied not only to onboard education but also to formal maritime education as a supplementary tool in the process of active and critical learning. Educational Games can be adjusted almost to any learning needs if it is designed under a framework such as the one it is proposed in this paper, and developed by a team formed by instructional designers, field masters educators, game designers and game developers.

Further work on this subject contains the development of the game described in this paper and the evaluation of its application to several cases in maritime industry.

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