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Computer game as means of Mine Risk Education for children

(Gra komputerowa jako środek do edukacji dzieci o ryzyku wynikającym z zaminowania)

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Educational computer game being the subject of this paper is developed by IMM as a part of an European FP7 Collaborative Integration Project named TIRAMISU (**T**oolbox **I**mplementation for **R**emoval of **A**nti-personnel **Mi**nes, **S**ubmunitions and **U**XO)(UXO – Unexploded Ordnance). TIRAMISU aims at providing the foundation for a global toolbox that will cover the main Mine Action activities, from the survey of large areas to the actual disposal of explosive hazards, including Mine Risk Education (MRE). The project has been planned for years 2012–2015 with participation of 24 partners from 11 countries. In this paper introductory information and assumptions making up a base for the game design are presented.

State of the art

Computer games find their application in education generally. They have "tremendous potential and level of capability as mediums of education", and many advantages because they offer: "agency, immersion, challenge, reward, immediacy, a dialect of repetition and variety, physical and mental engagement, and multi-sensory stimulation" [1]. As computer games advantages in education are considered also: "active participation, intrinsic and prompt feedback, challenging but achievable goals, and a certain degree of uncertainty and open-endedness" [2]. More complete list of attributes of the learning via computer games gives [3].

Specific aiming of educative computer games can be characterized – after [4] – as "to spawn objects, connect them with various constraints and thus create working systems that obey the laws of physics". Such applications can be found in chemistry (virtual laboratory), architectural design, biology (cell biology, virtual dissection), assembling (model of a car, experimental apparatus). Similar character have games with virtual lego bricks [5]. Advantages of this learning-by doing educational approach in computer games are discussed in [6]. Moreover – maybe first of all – there is a multitude of computer applicable means supporting school education at all levels, beginning from kindergarten, accessible in the Internet, many of them for free. Such means as educational songs and videos are among them, but many of them can be depicted as computer games (e.g. Learning Games for Kids http://www.learninggamesforkids.com/).

Beside distinction of games from other educational means, the distinction between computer games and simulation (training on simulators) is exposed as well in literature of the subject. In [7] simulation is depicted as "aimed at capturing elements of the real situation that are important to the training objectives", therefore, it "approximates real experiences" and is "complex and expensive". However, "games may only indirectly relate to the real world" and "can teach more than one idea at a time". Games involve competitions between individuals or groups, and at the same time "provide an incomplete or inaccurate view of reality". "Because some of the objectives are often hidden" – states the authors – game's participants "may leave a training session unaware of what was learned. For these reasons, the game must be carefully designed to meet training objectives".

As it has been expressed in the last attribute on the list given in [8], education can be conducted not only by playing computer games by learners, but – at higher level – by producing computer games by them. Toolkits enabling kids to create their own games have appeared in the Internet. One example is KidsRuby http://kidsruby.com/, generally oriented on learning how to program, and how to program games as well. Other example is Scratch http://scratch.mit.edu/, having already more than 3 million projects from around the world. Studies on use of this new tools in learning have been initiated also. [9] presents a study of this kind named "Making Games", which subject was making games by a group of 29 children 11–14 years old, with use of a toolkit "MissionMaker" http://www.immersiveeducation.eu/index.php/missionmakerm (now in use in over 200 schools across the United Kingdom). The study showed that children of this age are able to produce games with use of the accessible tools, as well as enabled to draw conclusions of general character on "conceptualization of the relationship between games and learning".

Many international and national bodies are engaged in the matter of educational computer games. GLS (Games + Learning + Society) http://www.gameslearningsociety.org/ is an example of society of such kind. GLS "is a group of videogame scholars and designers dedicated to doing more in these media environments" that combines academic staff and students with industry game designers. An example of dedicated journal is the International Journal of Learning and Media (IJLM) http://ijlm.net/about-ijlm. IJLM is a forum for scholars, researchers, and practitioners to discuss "theoretical, textual, historical, and sociological dimensions of media and learning, as well as the practical and political issues at stake".

Computer games are taking their first steps at MRE. Probably the first one was the game "Undercover UXO" http://undercoveruxo.org/, developed at the Michigan University and piloted in Cambodia by the Golden West Humanitarian Foundation http://www.goldenwesthf.org/ [10]. The game was designed with a $78,000 grant from the U.S. State Department, for the XO-1 computer developed as "$100 laptop" in the project One Laptop per Child (OLPC) http://wiki.laptop.org/go/The_OLPC_Wiki. However XO-1 actually costs nearly $200 and "hasn't really caught on globally", therefore present version of the game can be used on PCs as well. In gameplay children lead their avatar-pets (dogs or goats) in search of food through a photo-realistic terrain, recognizing explicit cues – a skull-and bones sign, or less obvious tip-offs, such as a barbed-wire fence – and learning to spot and avoid danger signs, like abandoned vehicles or animal remains. When danger is spotted, a player can call the "inspector" to make the area safe. Walking into a danger zone leads to an explosion. The inspector highlights the indicator, and the player begins again. The game was tested in Cambodia in 2010 [11]. There were two rounds of testing with groups of approximately 20 children. The first round took place at the Golden West Humanitarian Foundation offices in Phnom Penh with participation of children from a neighboring school. The second round took place in an orphanage located in a rural suburb of Phnom Penh. The result of testing "was a big success".

The second MRE game announced in public media is "EvilToys" http://www.rhok.org/problems/eviltoys-mine-risk-education-children-using-3d-game.

The game, still under development, is designed by Ahmed Mansour for the OLPC computer and adapted also for portable play station [12]. The scene of the game is virtual landmine museum "where the child has the opportunity to see and recognize shape of most commonly used mines on a table and get close to them without exploding, and recognize several kind of danger signs".

General characteristics

Basic profile

Reaching for computer games as a method of children MRE, the method finding its implementation in one of TIRAMISU tools, doesn't result from any pressing need of people living, and demining community engaged, on territories of present hot military conflicts. Computer games' postulated application isn't focused on instant remedying of bad accidents on a given territory, but games are to be designed for promoting behavioral change i.e. they are to form safe children behavior in the face of – rather permanent – mine risk. Thus, existence of ERW (Explosive Remnants of War) as a long-term or residual problem of successive generations of people is a target situation of computer games use for children MRE. Development of such long range tool in TIRAMISU is justified by the fact that TIRAMISU is a project of the 7th Framework Programme "for research, technological development and demonstration activities". Appropriately to this "the philosophy of the TIRAMISU project is to concentrate most of its efforts, not on already existing technology, but on the most mature technologies and methods that are still to be fielded and on promising and innovating solutions even if they may require more work to be fielded".

Such attitude is justified by international standards as well. IMAS 12.10 – Mine/ERW Risk Education in the item 5.3. states that "MRE approaches and methodologies likely to induce behavioural change". And also (items 9.5. and 9.6.) that MRE can be both "integrated into the school system and curriculum" and provided "as an extra curricula activity", just particularly "in countries facing a widespread and protracted mine or ERW problem, which is likely to be faced by successive generations of people". IMAS 07.11 – Guide for the management of mine risk education confirms promotion of behavioral change as an aim of MRE, and states also that education activities may be conducted in schools.

The following reasons should be taken into account for selection of types and characteristics of educational computer games that are to be developed in TIRAMISU.

- As it was stated previously after [7], computer games don't relate directly to the real world and don't provide complete and accurate view of reality. Moreover, because some objectives of a game are hidden, players can be unaware what is learned. Therefore the game has to be very carefully designed to meet training objectives .
- In the well mastered and dominant mainstream of computer games of current generation, games are "hardwired" i.e. they can be adapted/modified by its designers only (e.g. very popular game "Angry Birds" had its special off-the shelf editions on the occasions of Halloween and Valentine's Day).
- Children's educational games for use in the HD (Humanitarian Demining) risky area should be easily subjected to assessment in the psychological and ethical context, and controllable in these aspects.

Therefore TIRAMISU's games, created in present very initial phase of computer games application in the HD field, should be designed for rather permanent use in regular curricula than for ad hoc use for satisfying current needs in mine risk hot spots. Besides the assumption on developing TIRAMISU's MRE computer games as "hardwired" tools designed for use in school-like education, other assumptions should be formulated both for development in TIRAMISU current framework and beyond the project. These assumptions are related to: education objectives & ethical aspects, attractiveness & ethnicalization, and coming games' flexibility.

TIRAMISU's MRE computer games are dedicated to children 8-10 years of age, however as a result of psychological consultation planned for particular games that are to be developed, more detailed age-variants (i.e. below 8 and over 10) can be created. Psychological context of the games relates also to the following questions:

– what kind of game plot ought to be applied – pure realistic or fantastic as well;
– what kind of effects (visual, sound as well as plot incidents) should be applied as a consequence of dropping out of the game as a result of explosion; how to dose a horror;
– what kind of reward/satisfaction for right decisions in the form of game effects ought to be applied besides the score increase.

An internal, pre-deployment evaluation of the games is planned in one of the education centers in Poland. After necessary corrections games will be taken over to Croatia for assessment and then (provided a positive evaluation) will be introduced to selected school as extra curricula activity.

Attractiveness and ethnicalization

A key problem of usefulness of educational computer games is motivation of children to play them. In the case of entertainment computer games, being a free market product, attractiveness of games – depicted in this area as "addictiveness" – is only motivation. Addictiveness is obtained by rousing scenario with a rich repertoire of events, impressing video and sound effects.

Very advanced methods of games addictiveness measuring, based on "mind reading" with use of varied sensors have been developed [13] because just addictiveness decides on game's success on the market. In the case of educational games with strictly defined objectives, the possibility of attractiveness extension is really limited. But there is another motivation factor besides attractiveness – rivalry. And just motivation of children by possibility of entering a competition should be exploited in MRE computer games further development. So, suitable rating system, enabling calculation of individual and team scores should be designed for MRE games. Progress, both in MRE games scenarios and rating system design, ought to enable formation of successive games' levels that gameplayers can cover aiming at the highest possible score and rank.

The final result of going the way of motivation by rivalry could have a form of a permanent international MRE children gamers competition under auspices of a competent international institution, and with prizes significant financially and in prestige. Taking into account present and near-future possibilities offered by technology, the competition could be organized in the Internet with use of mobile equipment tested in TIRAMISU. Of course, design and implementation of trustworthy system for such competition is the future challenge.

The essential condition under which international competition can be organized is equality of chances and comparability of results of participants. So, MRE games making up the competition ground should be as universal as possible, should appeal to common characteristic of children of the human species – and just TIRAMISU's MRE games will be designed with respect to this assumption. Popular entertainment games (as e.g. previously cited "Angry Birds"), enthusiastically played by children of different cultures and ethnicity, confirm feasibility of this universal approach. Ethnicalization of MRE games, limited to necessary differences in language, landscape and photorealistic dangerous objects, can be treated as customization of a product with the same, unified general characteristics.

Flexibility and its consequences

As it was be stated previously, already now software toolkits enabling kids to create their own games are accessible. One can presume a trend toward computer games flexibility, i.e. the possibility to modify an original game by its users. Flexible MRE games could be adapted – not by playing children but by instructors/gameplay organizers – to local, current conditions. Such MRE games could serve not only to teach "standard" behavior regularly, but to give a knowledge and instruction related to occasional dangerous situations; they could be a new tool for use by MRE teams in their particular actions in a given area.

However future possibility of use of flexible MRE games would have significant consequences in different aspects. First of all, instructors/organizers should have specialist qualifications how to adapt games and how to conduct/supervise a gameplay. Next, ad hoc made modifications are in contradiction with the postulate of games "carefully designed to meet training objectives", and could lead toward teaching improper behavior in particular situations, not acceptable from ethical point of view, while ethical procedures assuring correctness are complex and long-lasting; psychological consultation can't be obtained in a simple way in these circumstances as well. At last a new communication infrastructure enabling to network players, instructor, and also other sources should be introduced. Maybe solutions adopted in BYOT (Bring Your Own Technology) systems – enabling students use of their own devices in school network – could be helpful.

Furthermore, with the above conditions taken into account, designing MRE computer games by children using suitable toolkits can be considered as a future MRE method, as well as the future subject of international competition.

Didactic aims

Didactic aims are defined as behavior recommended to children to avoid mine risk that ought to be taught by MRE computer games. And just teaching and strengthening of such behavior, in situations when there is still a possibility to avoid danger, is primary and initial aim in TIRAMISU MRE games. So, the game under development is to teach "don't touch dangerous objects" and "don't enter dangerous terrains" in relation to specified objects and terrains. It is worth to note that till now any systematic approach, acceptable from ethical point of view, haven't been developed in relation to children's behavior recommendation when a dangerous situation already occurred. What's more, one can find in different sources opposing advices how to behave. E.g. [14] reads: "Don't go to people who are injured or who are in an unsafe area. Fetch help". And [15] reads: "Help the mine victim to get out of the minefield according to the situation and not making other risks: you can also step on a landmine!"

Didactic aims include general recommendations for children and recommended specific behaviors.

General recommendations are the following.

- Attentively hear current information and instructions from adults, and comply with them.
- Inform carers where to go is planned, and don't go anywhere without their consent.
- If a child is in an unknown place then has to keep particular caution, to keep ears and eyes peeled, and to comply with learnt safety rules.
- Inform authorities and the community about the strange object recognized.
- Warn others about danger.

Technology

Design

The very first thing is that game concept must be developed. General game design and architecture have to be planned out including the various aspects the game will have.

The game design should contain.

- Game Foundations (Game Features, The Essence of the Gameplay, Characters, Game play Elements, Application Interface);
- User Interface (Navigational Chart, Functional Requirements, Objects of the User Interface);
- Graphics and Video (Graphics and Animations, Animated Insertions);
- Sounds and Music (General Description, Sound Effects, Music);
- Plot;
- Level Description (The graph of the Positional Relationship of the Levels, Queue of the New Objects Implementation, General Level Design Description).

Developing a detailed story line and the different play modes for game will help to plan the intricate details of the game at all stage.

Technical design should start with the choice of the proper game engine or if none available fits the game requirements, one should design the architecture for the game engine class.

Recommended specific behaviors are presented in the following Table.

Indicator of danger	Recommended behavior
Dangerous objects: − unknown objects − tripwire crossing the path − discarded packaging − wrapping and military debris	Don't touch
Terrain marked with table or/and ribbon as minefield or with traditional signs: − wooden cross put on the ground − crafted cross on a big tree − cut tree, broken branches across the road − wood placed on the ground − knot of high grass	Don't enter
Terrains and objects not marked but dangerous: − visible skeletons − injured or dead animal − old ammunition and its hole as the result of an explosion − visible craters − fortification − trench, shooting/launching position − bunker − dry wall − demolished building − deserted or a ruined house − road, path not in use − dug out − shelter − abandoned area − stone embankment − observation post − antenna system	Don't enter
Terrains and objects possibly dangerous: − edge of forest − overgrown area − high grass − dominant hill − ford − bridge − around water wells − along river banks, canals, streams	Prefer not enter/ choose another way, anyway keep increased caution

Mobile games

Game distribution depends on the targeted platform and technology which is used to build a game. In case of HTML5 games server delivers source code to the client e.g. an iPad which then runs the provided program and communicate with the server. Parts of the game source code can be cached on the client. Both iOS and Android allow to save the link to the game so it appears as the native application to the user. Server may be used to pair gamers, store their result, compare achievements with other players. It is often used to monitor and unlock new levels only when user completes the level before. More general every user action can be collected and saved for later retrieval.

Multiplayer architecture

In a traditional game developer sense, when a bunch of computers play a game together the easiest way to do it is to allow each game to actually simulate the state on its own and then transfer the state to all the other machines. This model is called a peer-to-peer networking so each game independently computes all the game state, rolls of a dice, positions of players, explosions, sends it to all the other clients which receive it and accept a game state of another player.

This methodology is actually really prone to lag or high latency and was the predominant way that games did multiplayer networking in the early '90s. Another problem with the peer-to-peer networking model is it is massively prone to cheating because every player is responsible for its state. Modern architecture for multiplayer games is the technology called the authoritative server. Instead of the clients actually calculating the game state themselves, a centralized server provides all calculations of the game state and then sends the results down to the clients. This means the clients are terminals and what they do is to take an input, send it to the server, receive game state and render the results of what the server tells them to do. This approach fixes cheating problem because the server is authoritative. It also helps a lot with lags and high latency so the quality of the game is now only dependent on the player network connection.

Games developed for native applications use platform dependent Application Programming Interface and specific to the system programming language. They often target only specific phones and operating system version. The most popular are the following platforms.

- **iOS** is the most mature platform. Applications are developed in Objective-C which is a combination of statically typed C programming language and Smalltalk object oriented and dynamic nature. Objective-C is a strict superset of C therefore it is very easy to use C and C++ libraries. For 3D development iOS provides C bindings to OpenGL ES 2.0. It is relatively easy target all devices with latest iOS version because devices running iOS share common resolution and/or aspect ratio. To develop applications Apple provides world best class tools including XCode with integrated Interface Builder and Instruments based on revolutionary DTrace technology. To make developer life easier number of game frameworks exist for the platform both commercial [16], [17] and free [18]. Application distribution is possible via Apple's own AppStore only. Application must obey Apple policy and be accepted through review process.
- **Android** is currently the fastest growing operating system. Being open-sourced it is adapted by many manufacturers among most successful ones are Samsung, HTC, Asus and Motorola.

Because of the open character of the operating system, manufacturers are allowed to develop devices with displays of different aspect ratios and resolutions. Companies releases new smartphones and tablets almost weekly. This led to fragmentation and in combination of manufacturers laziness in updating Android version on the released devices causes difficulties in developing software for Android operating system. Applications are built in Goggle version of Java and executed on the /Dalvik/ virtual machine. Android also provides Java bindings for OpenGL ES for 3D development and similarly there exist number of frameworks to make it easier for developers – [17] and cocos2d for Android based on [18]. Similarly to Apple AppStore Google allows developers to submit apps to Play store but unlike with iOS devices it is not the only way of installing software on the phone or tablet. Every user is free to install any software on their phone.

Cross-platform approach

Alike iOS and Android share common technology which is being said to be the future of mobile computing – HTML5. HTML5 in combination with JavaScript can be used to create all sorts of engaging and dynamic applications. It has brought about an explosion of new browser features like rich graphics, device access and advanced network connectivity. It is possible to take all this capabilities and create rich immersive game ex-

periences for users all over the Web. HTML5 is set to become the foundation of the upcoming mobile gaming era. Although still in development, HTML5 has been progressing much faster than previously anticipated. The HTML5 specification currently in /Working Draft/ state is supposed to be officially ratified by the end of 2014 and an HTML 5.1 specification Recommendation by the end of 2016 [19], but millions of developers and Web companies have already made the switch. Additionally extra benefits are that games built with HTML5 should be playable on desktop browsers with no or little modifications, given different peripherals devices. Several books have been written recently on the topic of HTML5 game development [20], [21], [22] describing important new technologies like /Canvas/, /WebGL/ and device access. Also of importance is the fact that Massive Open Online Courses (MOOC) sponsored by Google promote HTML5 Game Development [23].

There have been several games developed in HTML5 [24]. The following list presents best games developed in HTML5:

– Emberwind, developed by Opera Software is fantastic example what is possible to do using web tools [25];
– Angry Birds, port of the famous game from iOS to the web [26];
– Cut the Rope, another port from iOS [27].

Solution for TIRAMISU games

Best devices to develop HTML5 application are those with best manufacturer support. All Apple devices come with unspoken promise of years of support, e.g iPhone 3GS received all software updates for last 3.5 years. Taking into account all of the above for building networked multiplayer board games the following technologies look reasonably well:

– HTML 5 and accompanying standards like WebSocket;
– Client – Server Architecture;
– iOS as a target development platform with options to port application to Android and other HTML5 capable platforms;
– development devices iPhone 5 and iPad Mini (assuming future constant price drop of this devices).

At this point in time it is hard to tell which or even if any commercial applications or services will be needed. One possibility is to use messaging platform for multiplayer games (like http://pusher.com or http://www.pubnub.com) but it will depend on the future game requirements.

Summary

Computer games, although have found broad application in education, are taking their first steps at MRE. In the TIRAMISU project they have been chosen as appropriate tool for children's education, aimed at use in regular curricula forming safe children behavior in the face of permanent mine risk, not for ad hoc use for satisfying current needs in mine risk hot spots. An important problem of motivation of children to play the games, in the case of educational games with strictly defined didactic aims, can be solved by sporting competition rather then by plot attractiveness and impressing video and sound effects. The essential condition under which sporting competition can be organized is equality of chances and comparability of results of participants. So, MRE games should be as universal as possible, should appeal to common characteristic of children of the human species. Ethnicalization, limited to necessary differences in language, landscape and photorealistic dangerous objects, can be treated as customization of a product with the same, unified general characteristics. In the present, beginning approach to the MRE game design, the didactic aim is teaching rudimentary rules of safe behavior: "don't touch dangerous objects" and "don't enter dangerous terrains" in relation to specified objects and terrains. The TIRAMISU MRE game will be developed as a multiplayer mobile game in HTML5 standard, with Client-Server architecture, with iPhone 5 and iPad Mini as possible devices for gamers.

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