Game Mechanics of a Character Progression Multiplayer Role-Playing Game with Science Content

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Abstract. Current game-based learning designs incorporate the multiplayer component as delegation of tasks, with the meaning that individuals accept the game rules, interact with each other, but they do not necessarily share the same goals. We employed gameplay mechanics of the Multiplayer Role-Playing Games (MRPGs), such as character's progression and a turn-based battle system to encapsulate multiple aspects of science learning and to provide students with a tighter collaborative learning experience. SAIR is a chemistry MRPG that can be played with up to 4 persons. Further research should evaluate with students the influence of collaborative gameplay in science learning.

Keywords: Multiplayer Role-Playing games · Game design · Science education · Chemistry

1 Introduction

Role-Playing Games (RPGs) are a popular game genre that provides affordances for the integration of science and technology courses in playful learning environments [4]. There is a variety of serious games with chemistry content that have been designed to influence student attitudes towards Chemistry [8] or to integrate formal school curriculum [2, 4], employing game elements, such as pop-quiz questions, quests to be performed, and even a turn-based battle system [2, 4]. Minecraft in Education is a popular learning environment that combines the creative mode for building representations and applying the blocks' functionality [9] with the survival mode to give a playful character to the game. Although Minecraft has a first-person perspective, it incorporates the multiplayer component [13]. Ideally, collaboration requires players to share the same goal and to act together to maximize the team's utility [16]. From this viewpoint, collaboration in Minecraft occurs in a freeform (See Table 1. Multiplayer Science Games and this feature does not necessarily generate social game learning [9]. Similarly, Alkhimia is a Multiplayer Role-Playing Game (MRPG) with chemistry content. Players individually perform separation techniques, improving their weapons in a virtual lab and test them against monsters, making comparisons to understand the educational content (See Table 1. Multiplayer Science Games [12]. Massively Multiplayer Online (MMO) games

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could be also used in science classes to teach fundamental concepts to a big number of players. Shudayfat, et al. (2014) suggested a 3D MMO environment where students solve reaction quests by exploring for elements and solving puzzles to get the necessary materials. The game is cooperative, and therefore, students can communicate and help each other during the game, if they want (See Table 1. Multiplayer Science Games).

Table 1. Multiplayer science games with focus to chemistry

Chemistry game	Educational content	Connecting gaming with learning	Game's use in science classes	Multiplayer element
Mincraft Education	Open ended sandbox/science content	No	free form	cooperative
Alkhimia	A science inquiry/Chemistry	Separation techniques/improving the weapons.	Extra in-class curricula materials	cooperative
3D MMO	Chemical reactions	Reaction quests/searching & puzzle solving	Online use	cooperative

Game mechanics could strictly require players to act together to achieve the group's common goal. However, we did not find games that integrate science learning in such collaborative gameplay mechanics. Our aim is to integrate chemistry content in the gameplay mechanics of the MRPGs, We designed and developed MaSters of AIR (SAIR) for students who are 14 years old to learn and practice the school curriculum, connecting the content with real world applications and supporting meaningful collaborative learning. We decided to integrate the chapter of oxygen which includes the oxygen properties, the oxides, and the combustions, as they are described in the schoolbook [17]. We expect that this effort will become a blueprint for integrating chemistry content in the structure of MRPGs, providing an alternative educational tool for students and their teachers.

The rest of the paper is organized into the following sections. Section 2 describes the Game Design and Development while Sect. 3 discusses and concludes the study.

2 Game Design and Development

SAIR is an educational MRPG with chemistry content that can be played by up to 4 players, integrating social mechanics that can motivate student creativity and enhance learning. The game story is about a hidden formula with great powers which covers the earth, but that valuable information has been stolen. The alchemist guides our heroes to reveal those information through a series of challenges, such as exploration, riddles and problems to be solved, combats [1] etc. Through those processes, players increase their strength and progress the game-plot [10]. The storytelling, a core element of all RPGs [15] supported our effort to effectively present the content, using a graphic environment and various Non Playable Characters (NPCs) [11] and connecting the world

of atoms and molecules with observations of the macroscopic world. At the same time, the players learn and practice introductory chemistry curriculum, making connections with real-world applications. The integrated educational content regards oxygen, a basic component of the atmospheric air [17]. Learning occurs in the game through the interaction with the NPCs and the game world and additionally through collaboration among the party members.

The game's sequence in a rough timeline is used to identify the concrete components of the serious game activities and their connections, presenting the game's structure [3]. Therefore, SAIR is described from the following timeline (See Table 2).

Table 2. Game sequence

Game periods	Activities	Description
Game Intro.	Gaming	Introduction. Game period selection
Game period 1:	Gaming	Players reveal valuable information. Each one acquires a special skill. Players collaborate, combining those skills against their first enemy.
	Learning	Students learn the oxygen attributes. Students produce/detect oxygen.
	Instructional	NPCs introduce curriculum and guide players to perform tasks. NPCs challenge players & reward them with skills.
Game period 2:	Gaming	Players reveal more valuable information. Each player solves a problem to acquire a special skill. Players look for the volcano cave to find Chimera and combine their skills against it.
	Learning	Students learn to define oxides, to give examples, and to solve the chemical equations
	Instructional	NPCs introduce curriculum and guide players to perform tasks. NPCs challenge players & reward them with skills.
Game period 3:	Gaming	Players reveal more valuable information. Each player solves a problem and acquires a special skill of combustions. They travel with a hydrogen balloon, looking for the dragon. Players combine their skills, fighting the dragon to claim important materials.
	Learning	Students learn to define combustions, to give examples, and to solve chemical equations
	Instructional	NPCs introduce curriculum and guide players to perform tasks. NPCs challenge players & reward them with skills.
Game end	Gaming	Characters celebrate their victories

SAIR is based on a narrative and, therefore, players move in a 2D space, using their avatars and interacting with the game world. Players act as a party, performing together several quests in a free form, such as exploring the game world to find special items or

locations, using items to observe their reactions under the guidance of the NPCs etc. Moreover, SAIR uses a skill system that links student experimental observations and chemical equations solving with a turn-based battle system. The correct solution of riddles and problems awards players with skills that are required for the game progression, as enemies cannot be defeated without them. After all players have used their skills, it is possible to defeat an enemy on the turn-based battle system, a system that does not require quick reaction, but the players' acquired skills and strength (See Fig. 1). In particular, the battle system of SAIR is based on the feature of invulnerability, a state in which specified characters of the game are impervious to all damage. The fight with an invulnerable enemy is a fight that can force players to search for a special item or to acquire a special skill. Therefore, in SAIR each player must combine his/her skills with those of the other players against the invulnerability of an enemy (See Fig. 1). This will give the party the opportunity to defeat this enemy. That way, we facilitate collaboration among players in the game.

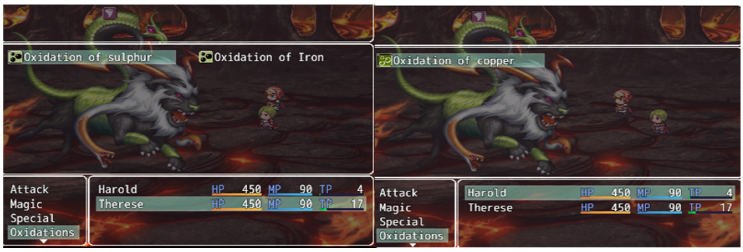

Fig. 1. Harold uses the oxidation of copper skill and therese uses the oxidations of sulfur and iron skills to defeat the chimera's invulnerability).

At the same time, students play the game to learn through active experimentation and reflective observation (See Fig. 2)

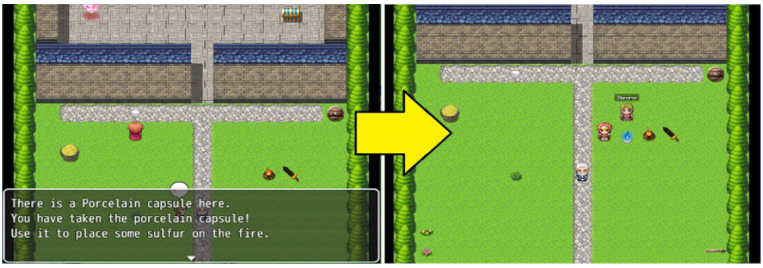

Fig. 2. Sulfur oxidation experiment.

Moreover, the students must not only remember and understand the educational content but additionally, they must be able to identify the content and to respond to related phenomena (See Fig. 3.)

Connections with real world applications are used throughout the game to empower science learning. Several examples have been used, e.g. students need to think where

Fig. 3. The riddle of volcano, sulfur dioxide combustion in an active volcano

fish find the oxygen they need, combining the oxygen attributes curriculum with their observations. Another example is that players use hydrogen as a fuel to fly to the dragon's land with a balloon, after learning about the hydrogen combustion or they collect woods to set up a fire for keeping themselves warm in the forest, learning, at the same time about the carbon combustion. In this way, the game activities promote meaningful learning through connections with the real world.

The instructional activities concern the ways that are used from the instructors or the game designers to facilitate learning. The various NPCs guide players to actively participate in the learning setting, providing guidance, feedback, and enhancing retention and transfer.

The game was developed with RPG MAKER MV (RMMV), a roleplaying game development engine published by Degica and developed by Kadokawa Games. [11].

3 Discussion and Future Research

We designed SAIR, a MRPG for 14 years old students to learn and practice science curriculum, connecting the content with real world applications and supporting students towards meaningful collaborative learning. The integration methods of science content with the MRPGs gameplay mechanics was achieved through a series of choices. The learning and the gaming activities were tightly connected through the RPGs storytelling and the characters' evolution features. Players in SAIR need to solve riddles and problems to acquire the necessary for the game's progression educational skills, under the guidance of the NPCs. Each player must combine his/her own educational skills with those of the other players against their enemy's invulnerability, in a turn-based battle system. Therefore, the integrated educational content is tightly connected with the playful character of the MRPGs, supporting collaborative science learning. Students have the opportunity to work together in small groups toward a common goal, becoming responsible for their own learning and gaining critical thinking [6].

Further research will elaborate on the game's design document as it could provide useful guidelines in the design and development of educational MRPGs. Another interesting parameter is the assessment of the collaborative gameplay with students.

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