

Designing Educational Computer Games to Enhance Teaching and Learning

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Abstract: The paper presents an overview of the potential of educational computer games for enhancing teaching and learning activities. When applied to educational contexts, educational computer games can enhance students' intrinsic motivation to learn, encourage learning by doing, encourage meaningful learning and provide risk-free environments which enable learners to explore and experiment.

Keywords: educational games, learning, teaching

I. Introduction

Constantly emerging new technologies challenge the field of education. The proper use of contemporary educational technologies can enhance learning and teaching. However, to be helpful, this technologies need to be incorporated in advanced pedagogical creative teaching practices.

The interest in using computer games for educational purposes has also increased over the last decade, with researchers identifying key pedagogical features that make good computer games inherently strong learning tools. When applied to educational contexts, educational computer games can:

- Enhance students' intrinsic motivation to learn;
- Encourage learning by doing;
- Encourage meaningful learning;
- Provide risk-free environments which enable learners to explore and experiment.

II. Games Definition And Characteristics

The term game could refer to: digital game (games that use a digital technology); electronic game (game consoles, online computer games, computer games on a PC); video game (television-linked consoles, portable video game systems); computer game (game played on a PC); online games; mobile game (game played on a mobile phone, mobile console, and tablet).

These games can be categorized as: educational games, leisure games and educational leisure games:

- Educational games are designed for educational purposes with explicit educational goals.
- Leisure games do not have learning as an explicit goal.
- Educational leisure games could be used successfully in educational environment to support teaching and learning although designed for leisure.

Game characteristics

Nicola Whitton proposed an approach which defines games according to key-characteristics. He stated that not all games necessarily include each of the characteristics and the more of these characteristics an activity exhibits, the more game-like it is considered to be.

- **Competition:** the aim of the educational activity is to achieve better results than other learners.
- **Challenge:** the educational task has a degree of difficulty and requires learning efforts.
- **Exploration:** the educational activity is performed in a simulated environment and the learner can discover and interact through exploration.
- **Fantasy:** fictional environment with characters that inhabit the virtual world.
- **Goals:** the educational game has clear objectives. The learners should know what they have to achieve
- **Interaction:** the game should provide feedback to the learner.
- **Outcomes:** the game should provide inform on the degree to which a goal has been achieved.
- **People:** learners can play in a competitive or collaborative manner.
- **Rules:** a set of instructions on how to play the game.
- **Safety:** environments that can be used without the consequences in the real world.

Game Platforms

There are distinctions among different electronic hardware. Digital games can be console-based or computer-based. The latest generation of consoles includes Microsoft's Xbox 360, Sony's Playstation 3 and Nintendo's Wii along with handheld devices such as the Nintendo DS and Sony PSP. While some games are console specific, many games can be played across multiple platforms [1].

This paper describes digital gaming, regardless of whether it is on a handheld, a console, or a PC.

Modes of Play

In addition, games can be characterized by the modes of play - some are single-player, and some are multiplayer; some are handheld and some are online.

- Single-Player mode - single-player mode allows one player to play on one platform;
- Multiplayer mode - although PCs and handheld games allow only a single player's experience, console games support multiplayer modality. All game consoles are manufactured with multiple controller ports so more than one player can play at a time;
- Network mode – network mode allows multiple players to play a single game simultaneously. The computers must be networked together, but the game may run either on a server on the network or through peer-to-peer connection;
- Online mode – online games are a subset of networked games with sufficient distinct characteristics. It is treated as a separate type of game according to these characteristics.

Game Genres

Games come from many different genres, including first-person shooters, role-playing, action, adventure, card, puzzle, and sports. Some are single-player, and some are multiplayer; some are handheld and some are online. Computer games, like books movies, come in a number of different genres. The literature offers the following categorization:

Adventure

Adventure-style games are typically story-driven and have one or more central characters. These games are perceived the most like movies and can rely heavily on dialogue, exploration, and logical problem solving to move the player through the narrative [2].

A classic example in this genre is the interactive fiction game *Myst*. The tasks in the game may be relevant to the curriculum and the learning process, often in terms of motivation, as in the case of *Civilization*, a widely popular and researched game that involves geography, history, and politics [3].

Shooting /Action

This category includes a different gameplay perspectives and subgenres. These games can include First Person Shooters (FPS) or other fighting games. Usually action games consist of tests of players' dexterity, reaction time, and quick-wittedness under pressure.

In shooter games, players typically aim and fire at moving objects to destroy them. This involves the development of fast hand to eye coordination and may be important in training areas associated with the police or military. In most cases the player operates virtual mechanical devices and has to accomplish some objective (e. g. drive a vehicle, fire a weapon or use a tool) [3].

Puzzle

Puzzle games primarily involve problem-solving, including words, logic, and mathematics. These types of games are based on traditional puzzles. Games that involve logic, problem solving, pattern matching, or all of the above fall into this game type. For example: *Tetris*, *Bejeweled*, *Sudoku* etc.

Strategy

Strategy games involve the player making strategic decisions within a scenario in order to meet the goal of the game, which is usually completing a level or solving a particular problem [4]. There are many good examples of this type of games, in the areas of history, economy, management, ecology, society, etc. Very popular and successful examples are: *Civilization* and *Age of Empires*.

Simulation

In simulation games, the player operates a model or simulation that behaves according to a programmed set of rules. Many simulation games focus on some element of realism, thus forcing players to understand and remember complex principles and relations and progress by trial-and-error [3].

These games are able to teach flying a plane up in the sky, steering a submarine deep in the ocean, etc. Good examples are Flight Simulator, Train Simulator, SimCity, etc. Social simulation games are also a large component in the simulation genre, for example The Sims. Another free simulation game for Business Project Management training is INNOV8, developed by IBM a few years ago and now reaching version 2 [5].

Role-Playing

A Role-Playing Game is a game in which the participants take the roles of fictional characters. The player can perform different activities - solving quests, fighting, treasure hunting, and interacting with other characters. In the context of learning, role-playing games are useful for providing a context for building collaborative skills, social interaction, and negotiation, management of complex systems (e.g. character statistics), strategy, and working through scenarios.

Sports

Sports games allow the player to simulate taking part in a sporting event or tournament. Sporting games can be used to practice the actual skills of a sport, tactics, rules and the ability to think and make decisions quickly.

Virtual Worlds

3D virtual worlds can provide opportunities for high sensory immersive experiences, with authentic contexts and activities for experiential learning, simulation and role-play, including the creation of complex environments and scenarios. A well-known example is Second Life which enables users to interact with each other through avatars. Players (residents) can explore the world, meet other residents, socialize, participate in individual and group activities, and create and trade virtual property and services with one another.

Traditional and Casual Games

Examples of such games are Chess, solitaire, and card games, online 2D or 3D spaces with obstacles to overcome. Casual games are divided into many small levels that follow the same pattern. They can be played for a few minutes at a time and easily stopped and restarted.

III. Using Educational Computer Games As An Educational Tool

The interest in using computer games for educational purposes has also increased over the last decade, with researchers identifying key pedagogical features that make good computer games inherently strong learning tools. A well designed game can teach higher order thinking skills such as strategic thinking, interpretative analysis, problem solving, plan formulation and execution, and adaptation to rapid change. These are the skills employers increasingly seek in workers and new workforce entrants. Games can also serve as powerful tools for teaching practical and technical skills. In addition, today's students who have grown up with the new ICT are especially ready to take advantage of the educational games.

The following benefits of gaming have been recognized by the Federation of American Scientists, the Entertainment Software Association, and the National Science Foundation convened a National Summit on Educational Games [6]:

Higher Order Skills:

- Think strategically about their positioning, analyse opponent strengths and weaknesses, plan how to achieve game goals, and execute those plans;
- Master resource management - managing people, money, food, and natural resources - and learn to acquire and apply force multipliers such as knowledge and technology;
- Interact with systems and understand the interaction of variables;
- Multi-task, manage complexity, respond to rapidly changing scenarios, and make decisions;
- Learn compromise and trade-off in satisfying the needs of diverse constituencies;
- Manage complex relationships;
- Exercise leadership, team building, negotiation, and collaboration.

Experiential Learning

The Experiential Learning promotes active learning, including planning, reflection and acquire theoretical knowledge in the following manner:

- Learning takes place as part of a sequence of steps where a learner starts by actively taking part in an educational process that provides a concrete experience;
- Personal reflection on the experience;

- This reflection is then followed by the application of known theories to the experience, or the derivation of rules from it;
- Learning is used to inform, modify and plan the next learning activity.

Practical Skills Training:

Through games and simulations, learners can exercise practical skills. This allows learners to train and practice without risking life or breaking up expensive equipment in the classroom. The learners can try again and again to acquire the required knowledge and skills.

High Performance Situations:

Games and simulations show promise in training individuals for high-performance situations that require complex and multicomponent decision-making. Characteristics of such situations include: rapidly evolving, ambiguous scenarios; time and performance pressures; the need for judgment; and high consequence for errors.

Rarely Used Skills:

Simulations are particularly important for reinforcing skills that are seldom used. For example: to practice students' responses to natural disaster situations.

Developing Expertise:

Games offer a way to learn how experts cope with the problems, creating mental models, or templates that they apply to different situations in their work. Games and simulations provide an opportunity to develop mental models more quickly to augment real-world experiences.

Collaborative Learning and Team Building:

Games offer opportunities to information sharing, goal-directed cooperation, and the spontaneous formation of relations - all critical skills demanded from the today's employers.

Educational computer games:

- Develop skills for effective work team, especially in decision-making, exercising judgment, and solving problems under pressure;
- Offer opportunities for teams to develop shared knowledge, and shared mental models that support implicit communications;
- Help teams improve communications among members by allowing them to develop information flows and practice task sequencing.
- Provide feedback - one of the benefits of computer games is the ability to provide the interaction and feedback that is crucial to the experiential learning cycle and to the whole learning process.

Problem-Based Learning

Problem-based learning involves small groups of students working together on real-life, cross-disciplinary problems. The teacher is facilitator rather than subject expert. Resources are provided to the students but information on how to cope with the problem is not provided. This encourages students taking more responsibility for their own learning, and learning in a real-world context [7].

Disadvantages of using computer games in education

Despite all the benefits that learning with computer games provides, there are some disadvantages. For instance [8]:

- High development costs;
- Slow change in educational institutions for adopting new innovations and new learning technologies;
- Some teachers have very negative attitudes about giving up textbooks in order to use educational gaming products;
- The specific educational values that are related to educational standards have not been proven;
- Games are especially good at teaching skills, which are not typically evaluated in traditional assessments.
- Lack of access to required technologies.

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- Long and slow change in educational institutions for adopting innovations and new educational technologies;

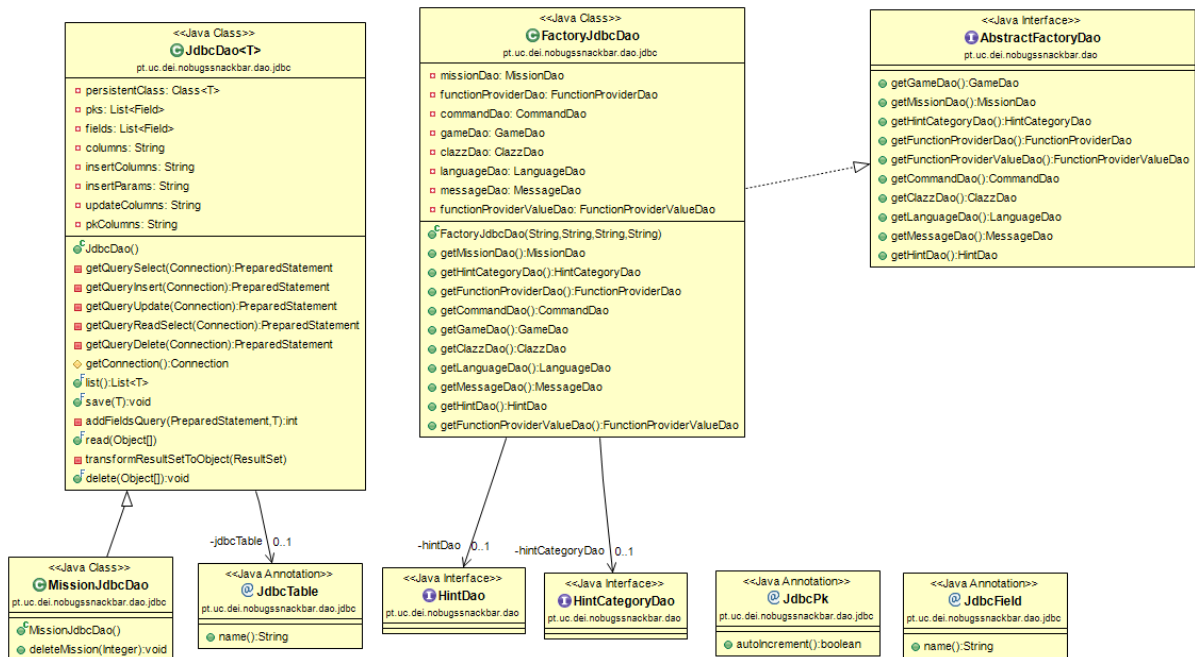


Figure 2. Class diagram of classes related to fetching from database

Use case diagrams - use case diagrams are valuable for visualizing the functional requirements of a system that will translate into design choices and development priorities.

The purpose of use case diagram is to capture the dynamic aspect of a system:

- To gather requirements of a system.
- To get an outside view of a system.
- To identify external and internal factors influencing the system.
- To show the interacting among the requirements are actors.

Since main use case diagram shown in 1 becomes very large and complex, it is divided to several diagrams, in which management of mission content will be reviewed in more details.

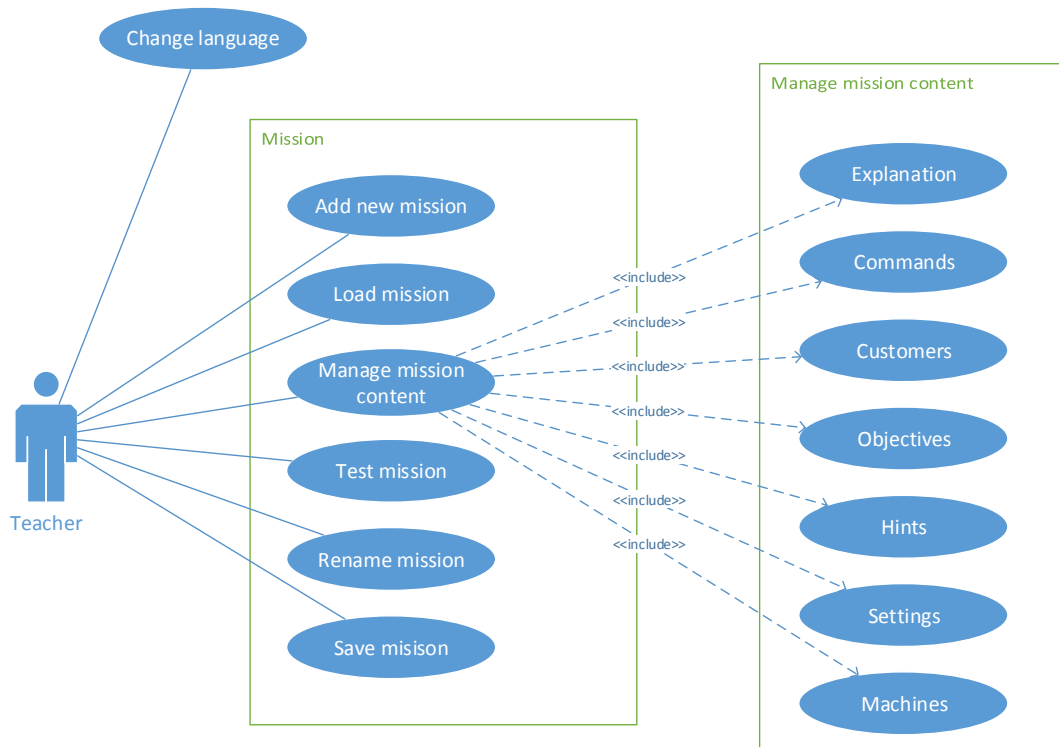


Figure 3. Use case diagram of mission

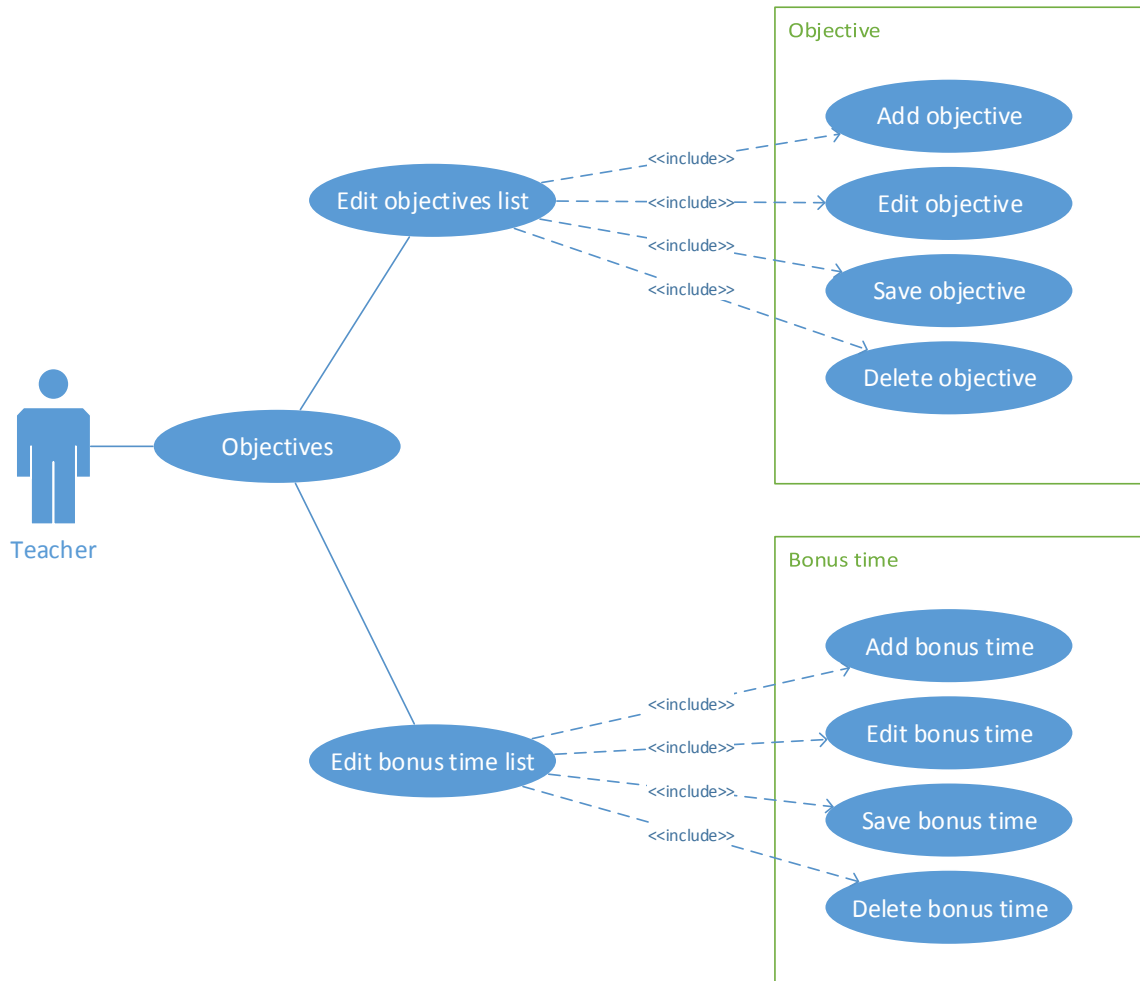


Figure4. Use case diagram of objectives

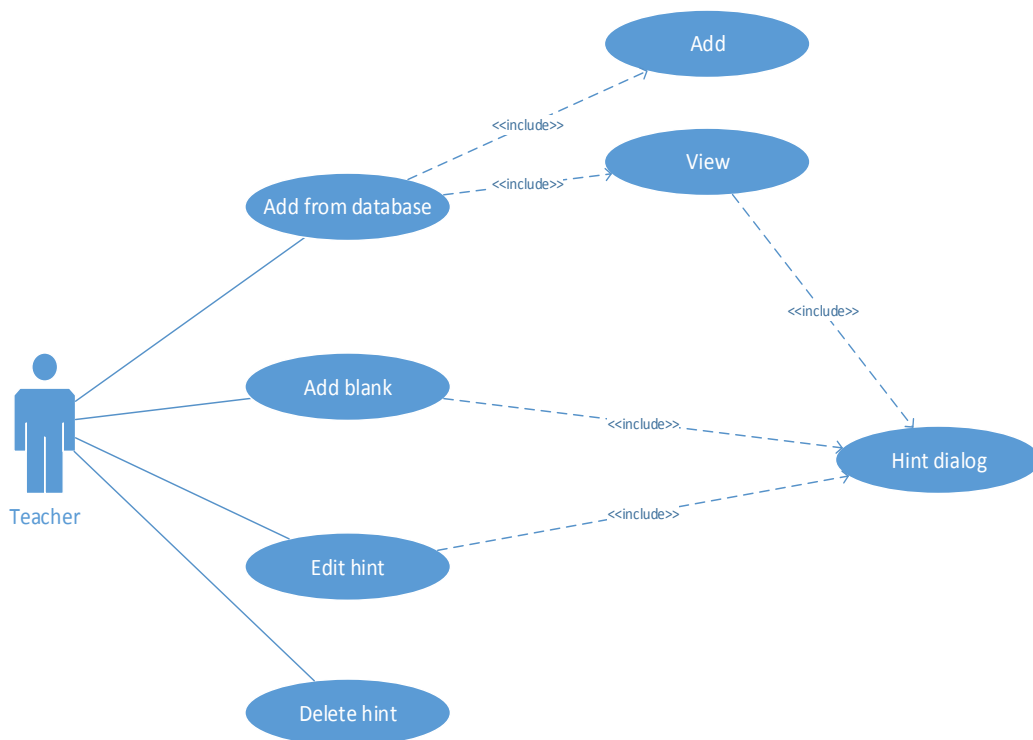


Figure5. Use case diagram of hints

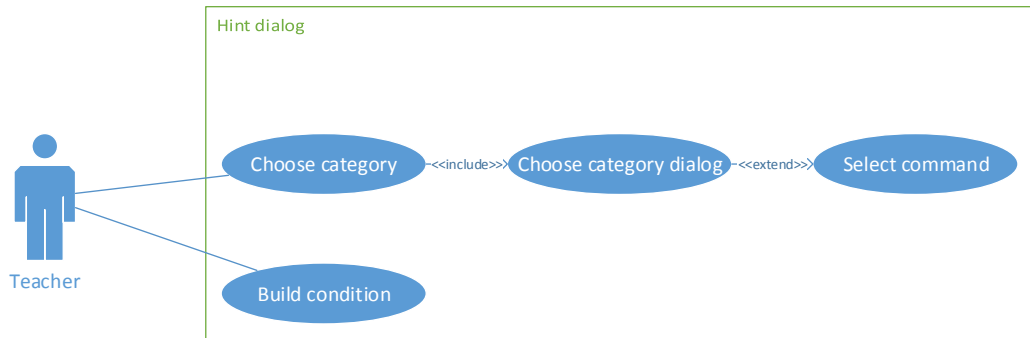


Figure6. Use case diagram of hint dialog

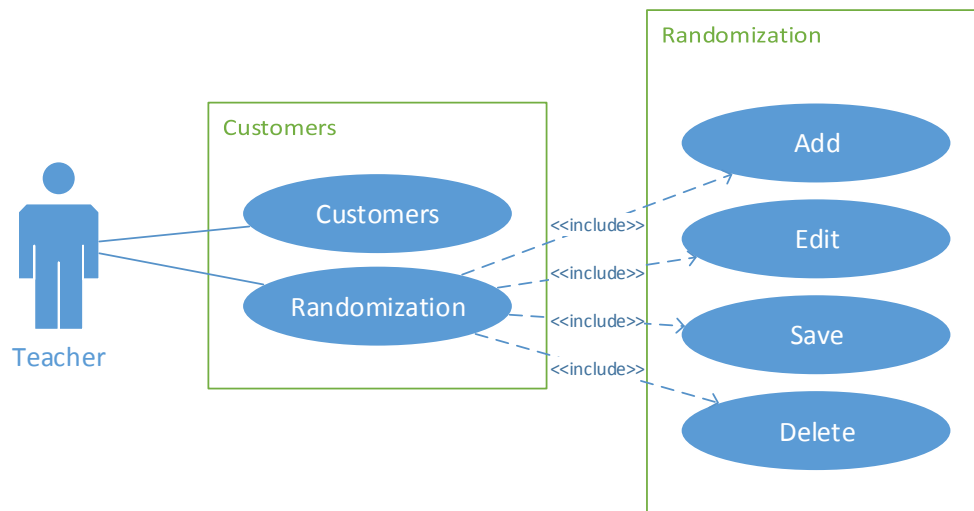


Figure7. Use case diagram of customers

Sequence diagrams

A Sequence diagram is an interaction diagram that shows how objects operate with one another and in what order. It shows object interactions arranged in time sequence and depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario.

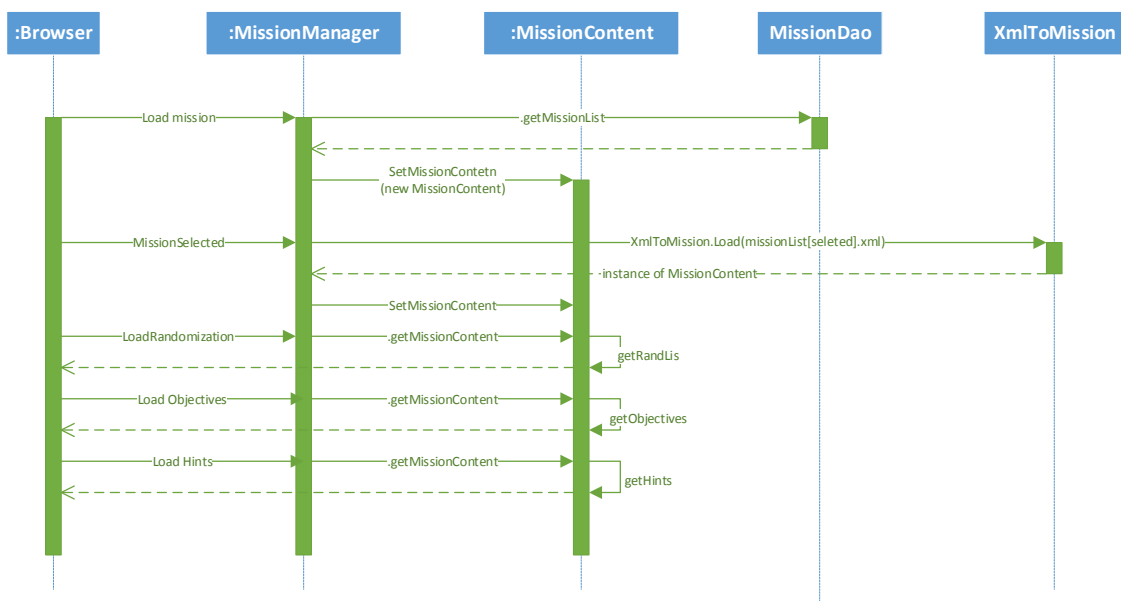


Figure 8. Sequence diagram for loading mission

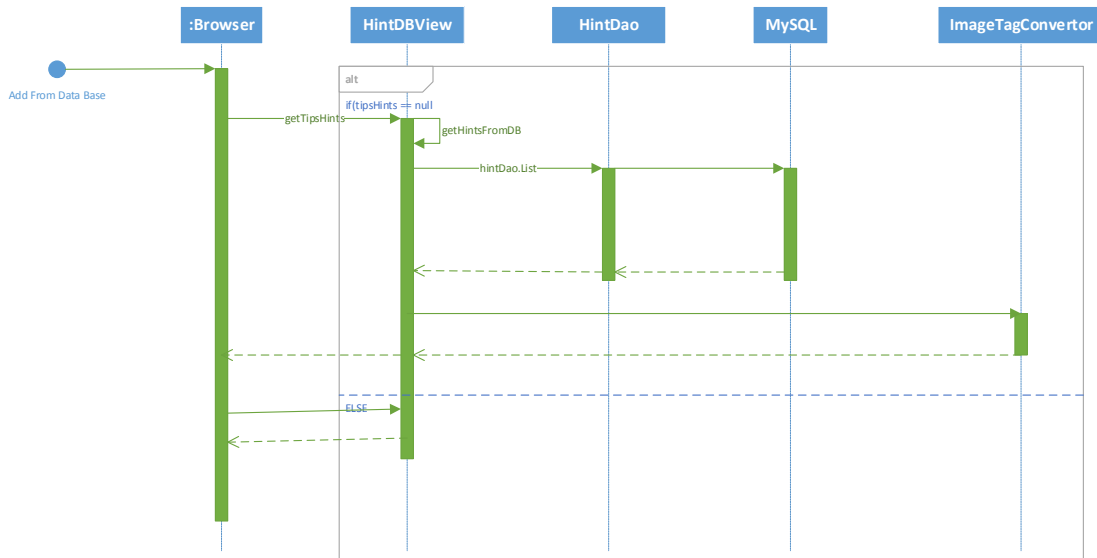


Figure 9. Sequence diagram for loading hints from database

Activity diagrams

Activity diagram is another important diagram in UML to describe dynamic aspects of the system. The basic purposes of activity diagrams are to capture the dynamic behavior of the system:

- Draw the activity flow of a system.
- Describe the sequence from one activity to another.
- Describe the parallel, branched and concurrent flow of the system.

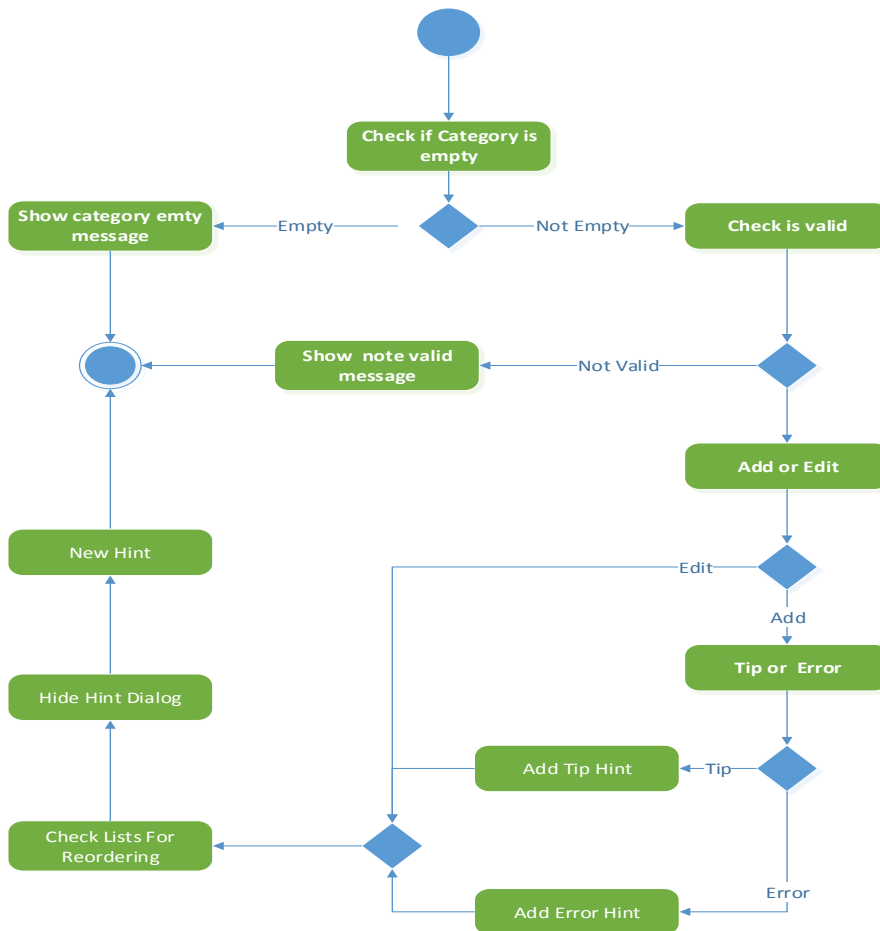


Figure 10. Activity diagram for adding hint

Programming language and environment

The project is developed with JavaServer Pages (JSP) technology. JSP is a server-side programming technology that enables the creation of dynamic, platform-independent method for building Web-based applications. JSP provides an elegant way to mix static and dynamic contents. The main page is written in regular HTML, while special tags are provided to insert pieces of Java programming codes. The advantages of JSP are:

- Separation of static and dynamic contents.
- Reuse of components and tag libraries.
- Java's power and portability.

The Web Server that supports JavaServer Pages and Servlets development is Tomcat. Apache Tomcat is an open source software implementation of the JavaServer Pages and Servlet technologies and can act as a standalone server for testing JSP and Servlets.

The database management system is My SQL - the most popular Open Source Relational SQL database management system. The advantages of using My SQL are:

- Released under an open-source license.
- Handles a large subset of the functionality of the most expensive and powerful database packages.
- Works on many operating systems and with many languages including PHP, C++, JAVA, etc.
- Customizable – allows programmers to modify the MySQL software.

V. Conclusion

When applied to educational contexts, educational computer games can enhance students' intrinsic motivation to learn, encourage learning by doing, encourage meaningful learning and provide risk-free environments which enable learners to explore and experiment. The value of computer games lies in the opportunity to combine the play with pedagogical advantages and to promote changes in cognitive, behavioral and psychomotor skills.

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