

Requirement Engineering in Game Development: A Necessity or an Overhead

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Abstract—Requirement Engineering is the first and the most important step in software development[11]. It is the stepping stone and all other phases depend on the requirement engineering for their successful completion. Game development is an area in which the application of Requirement Engineering is not clear and often in game development it is ignored. It is an area which requires a high level of creativity[7]. In this paper we will try to review the needs of requirement engineering processes in game development by going through the development processes that are followed. We will discuss whether the techniques used in Requirement Engineering are an overhead or a necessity. We will also discuss how game development differs from other forms of software development and how requirement engineering is done in it.

Keywords—Game development, requirement engineering, game-play

I. INTRODUCTION

Game development is different from other fields of software development. It is characterized by creativity and uncertainty. It is an area where engineering meets creativity [3]. Requirement engineering, which is one of the most important phase in software development is given very less importance in the field of game development. It is not common in gaming industry to collect requirements in advance [7]. This difference in importance for requirement engineering is due to the development processes that are employed in various game development companies. One of the reason for ignoring requirement engineering is the tight schedule of the project. Most projects in game industry are of 2-6 months which results in very less development time. The time pressure makes the stakeholder feel that requirement engineering may be a wastage of time.

There are many stakeholders of different backgrounds in game development such as designers, artists, subject matter experts, programmers and managers. Due to these different technical backgrounds sometimes it become very difficult to effectively communicate. The products in gaming world are developed for entertainment and not for a purely productive purpose [6]. Many of the gaming products are just a pass time. The user initially uses a game in his/her leisure period and it is the responsibility of the game to mesmerize a user in first few attempts. The user should feel himself/herself a part of the game.

Gaming softwares are the products which creates a virtual field where the user is given a situation, target or a war like

scenario and the aim of the user is clearly defined in start of the game. The necessary condition for a good gaming experience is that the user should feel like owner of the plot and not a simple player. These situations can only be created by following artistic and creative processes. It is the power of the imagination of a designer that can help in achieving such kind of immersive output that the user is convinced to play the game repeatedly.

II. HOW GAME DEVELOPMENT IS DIFFERENT

Game development is different from other software development fields in various aspects. Functional requirements of a system decides what a system is supposed to do where as non-functional requirements decides how the system should do. Game development focuses more on non-functional requirements rather than on functional requirements.

Fun is one of the most important non-functional requirement that is considered during development of games. It is one of the factors that make a game product a hit or a miss. Games are developed by stakeholders of wide variety. Due to this multidisciplinary requirement of talent, the game development becomes very complex as compared to other software development. Figure 1 shows various stakeholders that are present in game development.

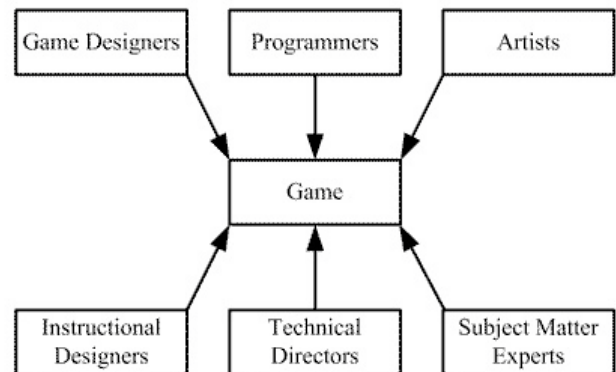


Fig. 1: Stakeholders in game development [5]

Game development companies mostly create their own ideas and make a prototype of the idea that is unanimously selected by the stakeholders. The idea of investment comes only after a working prototype is ready. In case of other

software products the requirements of a product mostly come from a customer. In case of game development requirements are initially quoted mainly by the game designers and these requirements are enriched and refined by user-testing and evaluations.

In case of game development it is often the case that final product is very different to the product that was expected when the product development started. This happens as the user-testing is given a lot of importance. Gaming products are always targeted to a special audience and it is very important to take feedback from a group of gamers that are in that domain. This feedback can be taken using various tools of requirement gathering that we will discuss in later sections.

III. LIFE CYCLE OF GAME DEVELOPMENT

Every software has a typical life cycle. Game development life cycle is different from traditional software development life cycle(SDLC). The Starting phases in Game development life cycle are extra phases as compared to a typical SDLC. These phases are very important for game development as this is where original idea of the game is generated. Game development process can be broadly divided into two main stages. The two stages are well elaborated in the following figure 2.

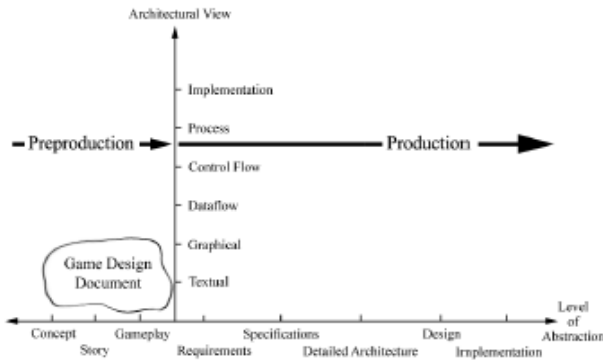


Fig. 2: Life cycle of game development [3]

A. Preproduction Stage

Preproduction stage is the first stage in game development. In this stage the first step is to discuss the potential ideas for the game. The game ideas are discussed using Brainstorming. It is a very effective tool and is widely used in game development.

Brainstorming sessions are held between various stakeholders in order to discuss various creative ideas. A small discussion is done on every idea. While discussing the idea various parameters are discussed such as the targeted audience and return on investment. These discussions are held with an intent to be constructive and so everybody is encouraged to give the ideas. The process of idea selection is very important as the success of the product solely depend on the idea.

After some brainstorming sessions, an idea is selected. The next step is to create a detailed document containing all

the requirements of the game. This document is called Game Design Document(GDD). Preproduction stage is basically an organisation's internal effort to define their needs and expectations from the product.

In this phase functional requirements are never discussed but the fun and enjoyment part is the main focus. Game mechanics such as concept, basic rules, themes, characters, environment and story are finalized. Game idea is vague at this stage and it refines more and more as the production stage begins and a prototype is made.

B. Production Stage

The production phase uses the GDD provided by the preproduction phase and convert it into a specification. Requirement Engineering that is done to convert the GDD into concrete specifications is done by various stakeholders. Once the specifications are completed, a normal software development life cycle is followed to complete the first prototype of the game.

Prototyping is very necessary as there are various organisations that depend on external funding for their product. In such a case the prototype is the product that is used in idea pitching. Idea pitching is the process of explaining the plot and main selling point of the game to a potential investor or the senior management in a company. After the prototyping phase, various organization follow different approaches of development which we will discuss in detail in later sections.

The main challenge in game development is the smooth transition from preproduction stage to production stage. This transition if done properly can lead to a smooth development process in production stage.

IV. GAMEPLAY

Gameplay is a term used for explaining the way in which a player interacts with the game. It is very important for a game to provide a good gameplay in order to become a hit. It is aptly defined as the capacity of seducing the player to be deeply involved in the game [4]. This requirement is achieved by making the plot and rules of the game in such a way that the user is engaged with the game. It also includes the challenges in the game and how the user activities are related to those challenges. It is a combination of functional and non-functional requirements that are essential to a game in order to provide a successful gaming experience. Good gameplay is central to the success of the game [4].

It is one of the big challenges in front of the design team. It contains challenges such as capturing user's attention and balancing various emotional and experience requirements of the game [8]. There are three main components of gameplay [12]:

- Manipulation Rules: It defines what a player can do in the game.
- Goal Rules: It defines the goal of the game.
- Meta Rules: It defines the ways in which a game can be modified.

A. Playability

The quality of gameplay is often measured by the playability. It is the ease by which the game can be played or the quantity or duration that a game can be played. It is very important to design a game that will have such a playability that the user will be compelled to play it for long and repeated times. Playability can be broadly divided into two parts:

- 1) **Intrapersonal Playability**
It is defined as the experience that is felt by a player while they play the game. It has a highly subjective value.
- 2) **Interpersonal Playability**
It is defined as the group consciousness and different user perceptions that are made while the player plays the game with other players in a competitive, cooperative or collaborative way[12].

V. GAME DESIGN DOCUMENT

Game Design Document is a highly detailed document prepared by the preproduction team. Game design document is mainly created by the design team. The main goal of the GDD is to refine the features of the game in such a detail that it can be easily used for development processes in production stage. It is one of the crucial outcome of preproduction stage. The things that are included in the GDD are:

- **Concept statement and Tag line:** Every game should have a concept statement and a tag line. These two things should succinctly define the intent of the game.
- **The genre and story of the game:** Gaming world has several genres such as adventure, warfare etc. GDD contains the information about the genre of the game. The story of the game should be made in such a way that it emotionally captures the audience. GDD contains the story of the game in detail.
- **The characters in the game:** The character to be used in game are also mentioned in GDD. In gaming world the players are represented as avatars. The look and feel of all the avatars and characters is mentioned in GDD.

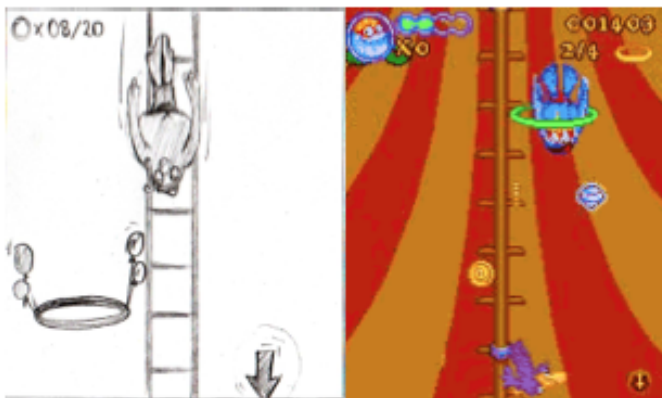


Fig. 3: A comparison between first design and final product [4]

- **How the game will be played:** Every game is limited by defining various rules and limitations that a player has to follow in order to survive in the game.
- **Look, feel and sound of the game:** The gaming environment is very important. It creates an augmented world for a player. Various sounds and visual effects that are used in game are also mentioned in this document in great detail.

Figure 3 shows a contrast of the first design and the final product of a game [4]. As we can see the game design is explained conceptually very well in GDD. There are cases when a lot of things can change and final product is very dissimilar to the conceptual design. This can happen after user testings and other evaluations. As it can be seen in this figure also that final product has many differences as compared to the initial design.

In the initial development cycles, GDD plays a very important role for developers. A good GDD removes the dependency on designers once the production starts.

VI. PROBLEMS IN GAME DEVELOPMENT

Requirement engineering is performed in various forms in field of game development. Although maximum efforts are done for determining non-functional requirements of the system. Many aspects of preproduction stage and production stage uses various tool for requirements analysis and identification. The field of game development has various aspects that lead to problems in doing a proper requirement engineering. Some of these problems are:

A. Communication

In game development, stakeholders of different technical expertise are involved. In these cases it is very difficult to communicate because of their different visions and domain knowledge. For example a Game designers may not understand the limitation of AI required when designing non-player characters while software engineers may not understand the creative vision [3]. Proper communication between stakeholders is necessary in order to have a good understanding of the system.

B. Time Constraint

It is one of the major reasons which results to poor requirement engineering. In game development shipping time of a typical game is 2-6 months. This time limitation results in less importance given to RE phase. This happens because a lot of stakeholders are of the view that a proper requirement engineering will waste a lot of time.

C. Personal Perception

Designers may be inclined to include their personal perceptions and interests. This happens in some cases when the designer is not experienced enough and they do not see the perspective of the user clearly and add things that appeals to them. This happens very rarely in places where a group of designers or stakeholders decide things unanimously.

D. Uncertainty

Game development is characterized by high level of uncertainty. There are cases when the projects are dropped in later stages after user testing. This happens because the product does not meet the target audience needs. Sometimes, better game ideas emerge during development phase. There are cases when projects are dropped after two or more iteration of projects in cases where the user evaluation is not coming satisfactory. It is very important to create a product that will sell and will at least break-even the efforts.

E. Requirement Conundrum

It is very difficult to decide that when should the requirement engineering be done. It should be done in preproduction stage or the production stage. Whether it should be stopped early in the production stage in case where a lot of requirements has been synthesized in preproduction stage. Moreover, non-functional requirements such as fun and enjoyment are very difficult to quantify.

F. Target Audience

In gaming world it is very important to recognize the right target audience of the product in early stages. The main problem is to know whether the product actually reflects the interests of the audience it is targeting. Suppose if the game is designed for children of age 8 to 12 then it is very important to capture the emotions of the children in the game so that they can relate to the game in a better way.

VII. SOURCES OF REQUIREMENT GATHERING

Collecting the correct requirements is always difficult specially in case of game development. Game development includes a lot of non-functional requirements such as experience and emotional requirements which are very difficult to evaluate and quantify. There are various sources for requirement gathering that are used in game development:

A. Users

As we already mentioned that the games are designed by keeping a target audience in mind. It is very important to get feedback from a group of users which likes to play that genre of the game. Most of the requirements are gathered using tools such as interview and surveys. The requirements gathering from users are not only done in the start of the game but also various prototypes are evaluated with the users. This feedback on prototype is very important and this often decides the fate of the product.

B. Vision of the company

The gaming products developed by an organization always depend on the vision of the company. Some companies have a vision to just get a good return on investment. They try to find a genre and product that is favourable and a similar product can be created. A good gaming organization always have a bigger vision. They want to make a product that can sensationalize the market and provide something that is unique and yet engaging. If a product is really good it is ought to make a huge return on investment.

C. Tools

Requirement gathering is very difficult but there are tools that help in extracting and verifying the requirements.

- Questionnaires: Questions in a questionnaire is designed in such a way that they can elicit more information from the user. Questions can be closed as well as open ended.
- Interviews: Various forms of interviews such as structured, semi-structured or unstructured interviews are used for eliciting requirements.
- Surveys: Surveys are preferred when the scope of the project is very large and requirement engineering needs to be done at a very large scale. This technique covers a large geographical area. The analysis of data can be done easily.
- Brainstorming: It is one of the important and most widely used technique in game development to collect requirements. This is a perfect tool in cases where there are a number of stakeholders.

These tools and techniques provide a good way to collect requirements in gaming organizations.

D. Creativity of the stakeholders

Creativity of the stakeholders is one of the main source of requirements. It is the creativity of the designers, artists and other stakeholders that create a world which makes the user feel that he/she is the part of that world. A good design and plot are something that is necessary to create an engaging experience and this can be achieved only if stakeholders are creative enough.

E. Testing of the game design

In game development testing plays an important role in refining the product. It is given more importance as compared to other fields. Various use cases are considered and output of these testings act as a valuable source for requirement gathering and identification. Sometimes testing can alter the original design and specifications of the game [7]

VIII. TYPES OF REQUIREMENTS

Requirements in software development are broadly classified into two categories:

A. Functional Requirements

These are the requirements that specify as to what a system should do. These include the results of a system in various situations. Use cases are included as to how should a system behave in various situation. In case of game development various functional requirements are:

- Rules and plot of the game: Various rules such as manipulation, goal and meta rules that are already discussed in gameplay section come under functional requirements of the game. It contains the situations which can lead to either winning or losing. For example in case of a warfare game the player has to

- **Ways of player interaction:** It is the way in which player interact with various characters of the game and its environment. The action that a player can take and their consequences are all functional properties of the system.

B. Non-Functional Requirements

- **Fun:** It is one of the most important non-functional requirements of the game. This is one of the element that is required in every game product. Fun and enjoyment is one of the goal that every game needs to achieve.
- **Aesthetic:** Gaming experience should be involving and it should be concerned with pure emotion and sensation. It should create such an environment for the player that the player get excited to play every time he/she get some time free.

- **Look and Feel:** Visual and audio effects should be synchronized with each other in such a way that player should feel it to be a real world.

1) *Emotional Requirements*: It is necessary to understand the emotional requirements that a game designer wants to capture. The subjective nature of emotions makes it really difficult to specify and implement them [9]. Developer has to understand the emotional feel that a designer wants to capture [2].

Figure 4 shows a plot of a situation in a game. As shown in the figure the inner room contains the enemy. The player is moving through the gallery. Now the designer want the player to feel as if he is approaching near an enemy. The designer uses sound and light to produce such an effect. The sound source is placed near the enemy and the sound is reflected in the gallery and as the player approaches near the room the sound keep on increasing. This effect gives an impression to the player that he is approaching a danger. The designer used lighting very efficiently by giving various effects such as dimming of light. Giving a dusky environment makes the situation more grave near the enemy. The designer wants to induce an emotion of fear by using different lighting and sound. It is very important to understand how a user will feel while playing the game. The emotional requirements make the gaming experience more engaging for the users [10].

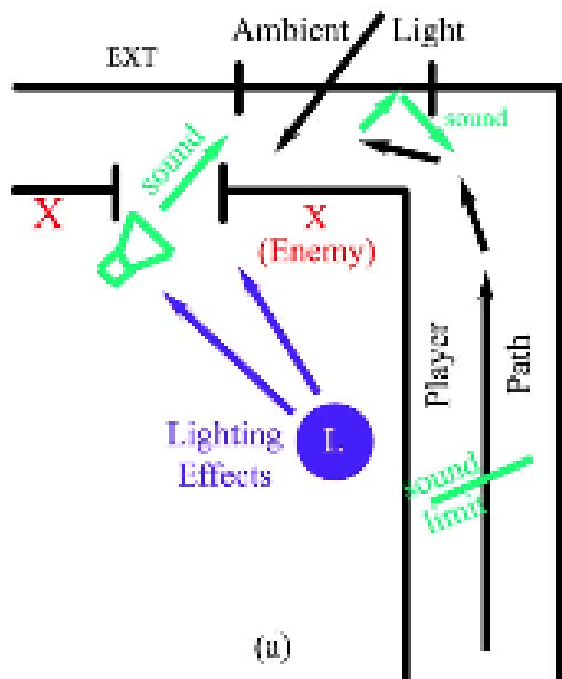


Fig. 4: A First Person Shooter Game Design [2]



Fig. 5: A Racing game Design [2]

Figure 5 shows an alternative situation of a racing game. Here the designer capture the emotional feeling of the player by using different situations in the track. The designer makes swift turns to increase the thrill in the game. Various recover regions are designed in the game to make a balance in the difficult and relax state of the player. This makes the user

more interested in the game as different scenarios come and the journey is not monotonous.

Although in case of first shooter game the emotional requirements is more because in the case of first shooter game the environment is build in continuation and the player should be immersively connected with characters through out the game. In case of car racing game the emotional feeling of the users are more involved in case where track is constructed in such a way that things can be unpredictable. This can be achieved by increasing the level of difficulty on run time if the user is found to more skilled.

2) *Experience Requirements*: Experience requirements are the description of the user experiences that must be met [1]. It has a larger scope. It defines the overall experience of a player while playing the game. While measuring this requirement gameplay and emotional experience are also considered.

It also provide guidance to player satisfaction testing. By documenting experience requirements properly we enable the testing team to validate that requirements easily. For example, if the specification says that that in a particular use-case the user should feel apprehensive then the testing team can verify this requirement by monitoring the player for the expected responses [1].

Advantages of documenting experience requirements:

- Appropriate test plans can be devised earlier in the process.
- It decreases the productions dependence upon the designers availability.

Experience requirement are extremely helpful in measuring the overall playing experience of the game. Although there are various advantages of documenting the experience requirement but the process can also make the designer conscious and it can hamper his/her creativity. It is very important to remain constructive while giving feedback. A negative atmosphere can kill the creativity and can make a designer feel as if his/her design will always be criticized. This can lead to less productivity of the designer.

IX. DEVELOPMENT MODELS

There are various kind of development models followed in gaming industry. This depends on the organization as to what kind of development model they follow based on their experience and knowledge. There are two development models that are mainly used in Game development.

A. Pipeline Model

It is a type of waterfall model. This is an ideal model of development in cases where a prototype is developed for proof-of-concept or for pitching purposes. The figure 6 shows a flow diagram of Pipeline model of development.

At first stage brainstorming sessions are completed and the game idea is finalized. After confirming the idea a prototype is developed as a proof-of-concept. This prototype is very helpful in pitching in cases where companies search for potential investors. In few cases a small user evaluation is also done using the prototype in order to know if the user will like this

product or not. Real development starts only when a return on investment is confirmed. After the development starts regular feedback is taken from testing in order to improve product.

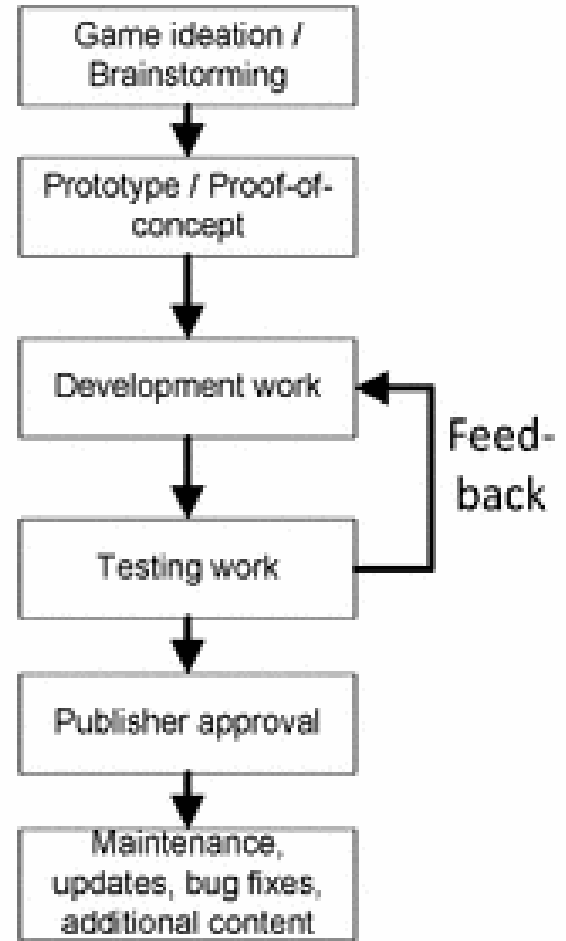


Fig. 6: Pipeline Model [7]

Once the testing approval is done the game is published after the publisher approval. This model is followed in organizations which are not willing to change the idea of the game drastically once the proper coding has started. In this model, testing is given less importance as compared to the iterative model of development [7]. Pipeline model is perfect for organization which have enough experience in gaming world and they have already released some successful games in the past.

B. Iterative Model

Iterative model is a prototype-driven incremental development model. This model is used in organizations which starts with a plan that is not complete [7]. A working prototype is made using the existing design knowledge. Existing features are tested and assessed periodically.

Figure 7 shows a working version of iteration model. As we can see in the figure that after every cycle, new requirements are generated by the testing and feedback from other sources

are generated. This feedback from various resources help in enriching the product.

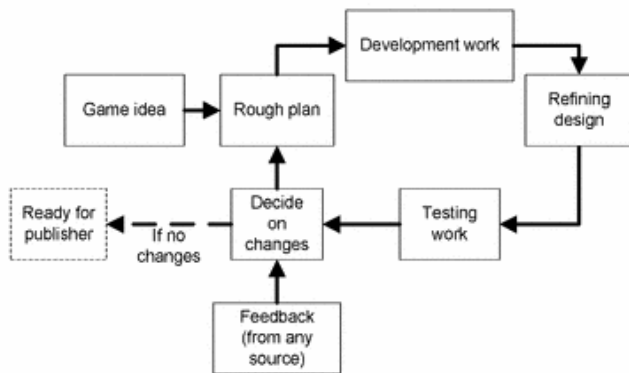


Fig. 7: Iteration Model [7]

This kind of model is followed by the organizations which are open for big changes in the concept of the game even after the development process has gone far. Feedback from testing and other sources is given great importance. Various iterations of the product are performed in order to get the best results from the testing, user evaluations and other sources. Once it is confirmed that the sources are liking the product, the game is released to the market.

X. OBSERVATIONS

In gaming organizations, product changes heavily between the first design and the final design. The design of the game enriches as the development cycle progresses. There are many cases where the original idea of the game originates in a later stage. We already mentioned that the user evaluation plays an important role on various features of the initial design of the game.

Feedback from marketing and testing can significantly change the product. As the testing of use cases can change the thinking of the designers as to what could be more enjoyable by the player of the game. Requirement analysis is done with user tests and usability testing as this is an effective way to gather requirements in game development.

Complexity of RE in game development is more because of uncertainty prevailing in the gaming world. As the whole product is dependent on an idea and the perception of whether it will be enjoyed or not. There are chances that few projects are even dropped or changed significantly in case user evaluations reveal that the product is not enjoyable by the players.

Game developers try to minimize the amount of functional requirements by using some third party engines. It is a common practise in game development to use third party engines for inheriting the physics and visual logic. It is not preferred to write game engines until it is required. The concentration is more on implementing non-functional requirements and more time is devoted on creating the look and feel.

Quality Assurance has more importance in game development domain. Quality assurance is one of the main source of

requirements in game development. In case of other software development field the testing is done only for validation of various cases but in case of game development it plays a crucial role.

Time constraint is one of the important feature in game development as most of the products in game development has a lifetime of 2-6 months. It is because of this constraint that requirements are not properly documented and which results in delay of products. As the market pressure is high on developers and artists they see requirement engineering as a wastage of time.

XI. CONCLUSION

Although most of the gaming organizations believe that they do not employ requirement engineering. We find that these organization actually depend heavily on requirement engineering for their successful completion. Gaming organizations have activities that can be characterized as requirement analysis and requirement identification [7]. In case of game development non-functional requirements are so wide that it is difficult to capture and explain each one of them.

In the preproduction stage various ideas are discussed in brainstorming sessions. Requirement engineering should not be done very deeply on all the ideas in preproduction stage but the idea should be refined enough before getting selected. There should be a measure in preproduction stage as to when to stop the requirement engineering. A detailed Requirement Engineering should be done after the idea has been identified..

As we have already discussed that gaming products goes through various iterations so new requirements are generated from the feedback received from the user. Often these requirements are not documented and this is one of the biggest mistake. These requirements should be documented properly and any missing requirement can cost one or more iteration which can be very costly in an organization where life cycle of the project is very short.

Non-functional requirement such as fun and entertainment are highly subjective. The measurement of these requirements is a big challenge. This can be solved by the early involvement of the user. An early involvement can give an insight to the designer as to what is missing in the design and plot of the game because of which it is not giving an entertainment feel to the user.

Game Design Document which is one of the main specification document that is prepared by the preproduction team should be fairly detailed. It should contain all the design and description of the game, from characters to different scenarios. It should be detailed and simple enough that production team can easily rely on it for development processes. This should be made with an intent to make the production team independent of the designer presence.

We came to the conclusion that requirement engineering is necessary for game development. If used properly, it can save a lot of development time and can result in more successful projects.

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