A

DISSERTATION REPORT

On

Play and Learn DS: Interactive and Gameful Learning of
Data Structures

Submitted to

LOVELY PROFESSIONAL UNIVERSITY
In partial fulfillment of the requirements for the award of degree of
MASTER OF PHILOSOPHY (M.phil)
IN
(Computer Science)

Submitted by:
Navneet kaur
Reg.no.11312413

Supervised by:
Dr.G.Geetha

SCHOOL OF COMPUTER APPLICATION
LOVELY PROFESSIONAL UNIVERSITY
PUNJAB

Certificate of the Supervisor

This is to certify that **Navneet kaur** has completed dissertation of Master of Philosophy (Computer Science) titled **"Play and Learn DS: Interactive and Gameful learning of Data Structure"** under my guidance and supervision. To the best of my knowledge, the present work is the result of her original analysis and study. No part of the project report has ever been submitted for any other degree or diploma.

The dissertation is fit for the submission and the partial fulfillment of the conditions for the award of M. Phil (Computer Science).

Date: **Signature of Supervisor**

Dr.G.Geetha

Declaration by the Candidate

I hereby declare that the dissertation titled **"Play and Learn DS: Interactive and Gameful learning of Data Structure"** is an authentic record of my own work carried out as requirement for the award of degree of M.phil (Computer Science) at Lovely Professional University, Phagwara, Punjab, India. The matter presented in the dissertation has not been submitted in part or full to any other university or institute for the award of any degree.

Date: **Signature of the Student**

Navneet kaur

Registration No: 11312413

Abstract

An improvement can be seen in the educational area in last few years due to the advances in mechanization, thus the expansion of academic applications is also increasing. One technique that has been recently used within this area is Gamification in which game mechanics can be used to make the applications fascinating and entertaining. Games can be used as a weapon for giving direction for all different forms of life. This concept has yield conclusive outcomes in many fields where it is newly used like education, health and marketing. Gamification gives a creating and fun learning framework in which students can learn through the visual manner, hence learning becomes more interesting. Through gamification, students can be able to clear concepts more effectively and precisely. In IT courses, Data Structure is the fundamental subject that is trained in different courses.

The current research work specifies the Design and Implementation of game, which will cover the main topics of data structure that should be clear to the students. As we can see that Data structure is the fundamental subject, and it is the base on different aspects. The game will raise the understanding on the subject and to engage students for developing the sense of self-learning.

Acknowledgement

I really would like to thanks to my Lord for giving me the privilege of writing this dissertation with immense of devotion and profound sense of gratitude.

With an overwhelming sense of pleasure and pride, I express my external appreciation and immensity to my esteemed guide, Dr.G.Geetha, Dean, Department of Computer Application, Lovely Professional University, Phagwara. Whose cordial guidance, motivating ideas and reassurance helped me in all the time of research and writing of this thesis.

I really feel short words to express my heartiest gratitude and sincere thanks to my parents, my loving brothers, my professors and my friends for their support and all they have comprised for me during tenure of my work.

Lastly and most importantly, I wish to thanks to all those who were directly and indirectly involved in the completion of this work thereby making it a total success.

Signature of Candidate

Navneet kaur

Table of Contents

List of Tables

List of Figures

List of Graphs

Chapter 1
Introduction

Gamification is a method to change the behavior of non game application. It is used in different types of applications to gain the engagement of user who will give return on investment and quality to data and provides learning. It is a new technique that affects the behavior and motivates the peoples. Game methods are the rules of the game used to make the task enjoyable. The business entities now start understanding the power of gamification as it improves the customer engagement and helpful to incent employees and their partners to perform at higher levels. Gamification has the ability to solve different problems outside the business entities as well, in such domains like health, education, etc., Game design is the process of using game methods to create a game environment that authorizes people for playing a game to have fun and engaging experience.

Humans have been playing games since the early days, and competition has deeply entered into the human being brain. At a rate of knots to the modern day with a significant amount of free time that people have today, gaming has become a hugely favoured and tremendous popular industry. Given this wide utilization of game mechanics and the internet, people have become more open to the game mechanics in alternative parts of their lives. As a consequence gamification has become a more popular way by which organizations teach and motivate people. Many tasks that people perform today use game mechanisms.

Gamification is a mechanism for effecting and motivating the behavior of persons - they can be anyone like customers, employees, students, patients, etc. Any person can be the participant of gamification who wants to engage or to change their performance.

This thesis aims at the use of concepts of gamification in the learning process. A framework has been developed for the interactive and gameful

learning of the subject Data Structure. The main cause of research work is to use the gamifying concepts in DS for creating motivation and to improve the process of learning DS. Different Data Structures have been used in the framework that is more typical and more important in computer courses.

1.1 Objective

The primary conjecture of this work is to provide an approach that deals with the problems faced by the new students in understanding the basic concepts of data structure. The hypothesis of the current study is to solve the problem through the application and achieving aims that are shown below:

AIM 1: To develop the framework for interactive and gameful learning of DS for creating

motivation.

AIM 2: To improve the learning process of DS.

1.2 Basic Concepts and Definitions

1.2.1 Games

Games are used by us in regular life. These are also considered as a part how we talk about day to day things. Like there is a game that is used in everyday life, i.e. customer service game. However, it is not considered as a proper game, but it is mostly similar as games. You have to perform the things as stated in the rules and regulations. There are certain aims in the game that the users try to achieve by playing that game.

1.2.2 Game Players

There are distinct types of reasons for playing different sorts of games. Players play with different ambition. Players are known as winners who perform in the environment and trying to achieve the goals [30]. There are different types of players like socializers who play games to interact with other people, explorer who always likes to solve puzzles.
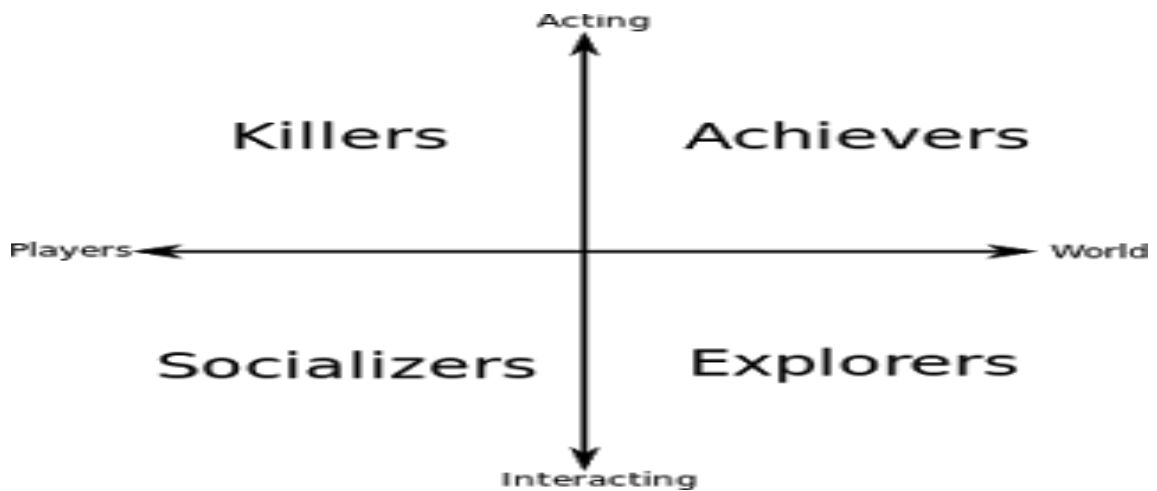
Figure 1.1 Bartle's Player Type [30]

1.2.3 Flow

The professor of psychology Mihaly Czikszentmihalyi [15], proposed a different kind of happiness that is known as "Flow." Flow is considered as a main creator of playing games by people. To improve flow the main objective is to achieve a fully challenged goal. The idea of flow is delineated in the figure below along with the level of a challenge. Challenge art balance is the nucleus element of the flow concept. To improve flow both the challenge and art of balance should be at top level. In the figure of flow, we can see that if the skill is not appropriate to challenge, then the complication of anxiety occurs, but if the skill is more than the challenge then the trouble of boredom can occur. Thus, there should be a balance between challenge and skill.
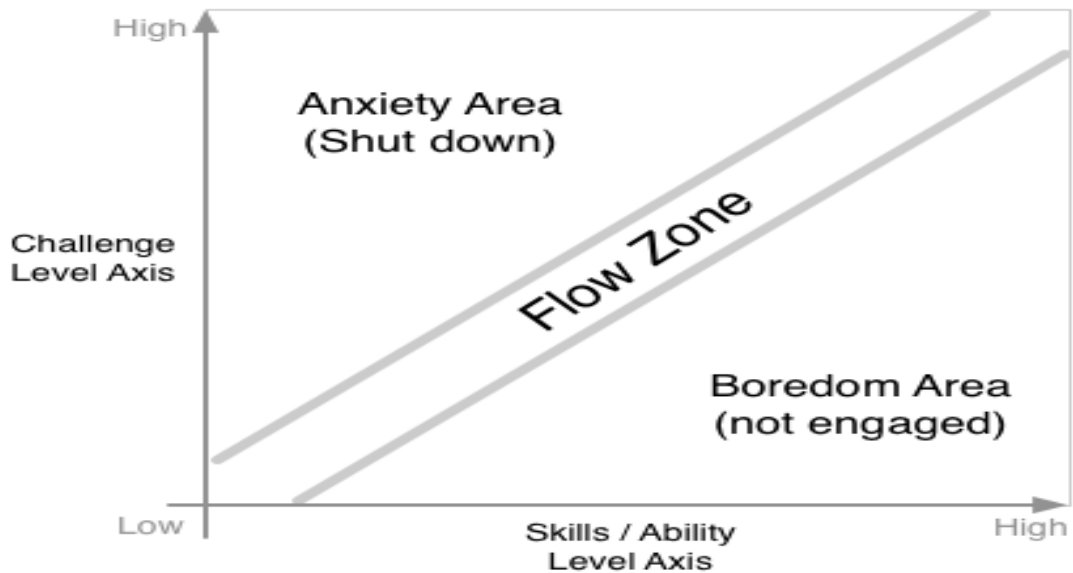
Figure 1.2: The Flow Zone (Mihaly Czikszentmihalyi, 1991) [15]

1.2.4 Fogg Behavior Model

The researcher BJ Fogg of Stanford University designed a Fogg behavior model. This model gives details about the reasons of change in performance. There are three factors in this model that will describe the behavior change, i.e. Motivation, Ability and Trigger [15]. Motivation- the user wants to perform the behavior, ability- the person can attain the behavior and the person is triggered to do the behavior.
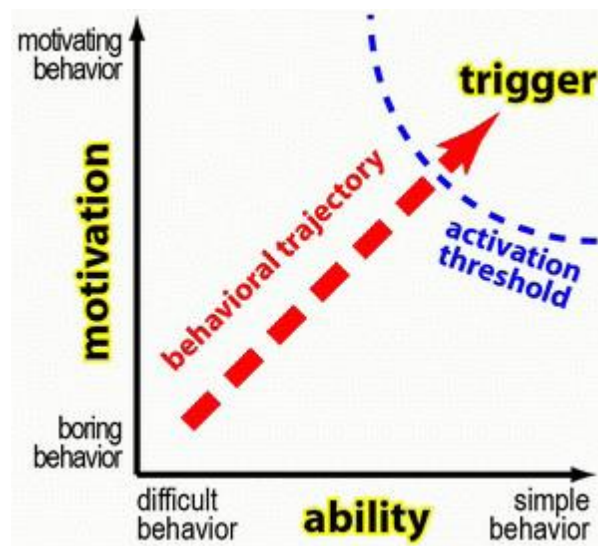
Figure 1.3: The Fogg Behavior Model [15]

1.2.5 Game Elements

There are certain types of game elements that can be used in games. In the figure below there is a pyramid that gives knowledge about the game elements [27]. The elements in a pyramid are split into three levels, i.e. dynamics, mechanics and components. The elements are organized in decreasing order of abstraction. In a model, Dynamics comes on first level, Mechanics on the second level and components on third level. Lower level components can be used to attain greater level goals [27]. Inherently, the dynamics are chosen, then mechanics and components [27].
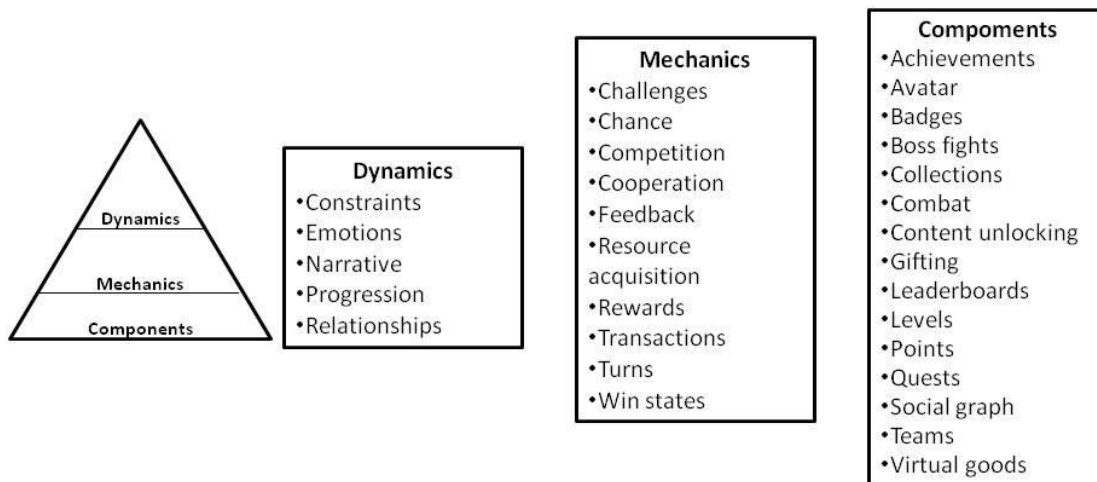
Figure 1.4 Pyramid of game elements (Werbach & Hunter 2012: 78) [28]

1.2.5.1 Dynamics

Dynamics are on the first level. These are the main parts of the games. Games are revolved around these elements. Dynamics are divided into five parts, i.e. constraints mean some types of rules and regulations; emotions mean different types of emotions like joy and sadness, narrative is a structure that makes the game into a coherent whole; progression is moving forward and improving; relationships mean interaction of one user to another user.

1.2.5.2 Mechanics

Mechanics imply towards more specific actions. Different sort of mechanics that are used in games are challenges, chance, cooperation, competition, feedback, resource acquisition, rewards, transactions, turns, etc., For example, feedback and rewards are used for giving the feel of progression.

Table 1.1 Connection between game dynamics and game mechanics [29]

Game Mechanics	Game Dynamics
Points	Reward
Levels	Status
Challenges	Achievement
Virtual goods and spaces	Self-expression
Leaderboards	Competition
Gifts and charity	Altruism

1.2.5.3 Components

Components are the elements that are used in the framework of the game. Components come at the last level. Like event unlocking can be a part of the rewards. Different types of components that are used in games are achievements, badges, boss fights, content unlocking, collections, gifting, leader boards, levels, points, quests, etc.

1.2.6 Design Process of Game

There is not any specific design for the game process because it depends on the needs of users. Kevin Werbach proposed six step sequential design process, which is discussed below. This design focuses on giving knowledge about how to use the available game elements in a particular situation.

Step 1: Define Business Objectives: The first step of the design process is to define the objectives of the business. The objectives should be effective.

Step 2: Delineate Target Behaviors: The second step is to delineate the target behavior. The behavior of the target user should be properly measured. The target behavior should achieve the business objectives.

Step 3: Describe Players: Next step of the design process is to describe the users. These should be properly selected.

Step 4: Develop Game Design: In the fourth step, the design of the game is being developed. In game design the rules, feedback, game elements and characteristics of the gamified environment is being described.

Step 5: Implement Game: After describing the design of gamified environment the implementation starts.

Step 6: Review and Adapt: After the implementation, the game is being reviewed that if it meets its goals or not. If the game is successful in achieving its goals, then it is adapted by the users.

1.2.7 Examples of Gamification

There are many applications that are using the elements of gamification. There are few examples of those applications that are practicing the game design elements.

1.2.7.1 EMO-BIN [31]

EMO – BIN is a recycle bin that uses smiles and sound for rewarding the users. When the user recycles, then the bin will smiles. It can be seen that by using emotions in the recycle bin, the rate of recycling has been expanded by the factor of x3 [31].

Figure 1.5 Student recycling with emo-bin. [31]

1.2.7.2 CAPTCHINO [6]

CAPTCHINO is a technique that is used with aim of security purpose. Previously, text-based captchas were in used. However, now picture based captchas are mostly used. Captchino is a single-user game, in which user solves the game that is in the structure of test. This activity has six rounds and in every round, there is some picture based captchas which the user has to solve before going to next step.

1.2.7.3 FOUR SQUARE [43]

It is a game that is based on the location in which participants have to check-in for gaining the points and rewards. It is the most used example of using game elements in the location based applications. This game uses points, levels, badges, and leader boards for engaging the participant for the visit that particular location again. It shows that the simple game mechanics can be helpful in changing the behavior of the user.

1.2.8 Interactive Learning

Interactive learning is a pedagogical way that deals with social networking and newest computing in course design. Interactive learning comes out in the rapid growth through the use of newer digital technology by students. From 2000, Students of higher education demands the use of interactive learning of their courses. The use of latest digital media in courses makes the interactive learning popular.

1.2.8.1 Components of interactive learning:

Public Media: The benefit of public network like Facebook and My Space connects lots of learners to the online community where knowledge is exchanged totally to students and teachers.

Latest Computing: It includes the use of WI-Fi network, smart phones and much more digital media.

Serious Games: It provides knowledge by playing the games.

Chapter 2

Literature Review

2.1 Review of Literature

Erenli [1], proposed a gamification mechanism for teaching purpose. The Author has described the history of gamification, and then he tried to describe the impact of gamification method on teaching. He has used the well researched facts to discuss the potential. Scenarios have been evaluated for teachers and to use and adopt this mechanism of gamification. He has also described the importance of gamification in social society. He describes that how gamification can be useful to engage students and to motivate them.

Bista and Nepal [2], proposed an architecture and application of gamification mechanics for networked communities. Badges based gamification has been opted for monitoring the online communities. Their aim for proposing this model was to improve three basic issues of community like bootstrapping, monitoring, sustainability. They have described their point and badges based design of gamification. Badge data analysis helps to community observers to monitor the community at a glance.

Kanat et al. [3], proposed architecture for game to use it in the purpose of emergency response training. The use game can reduce the cost of training if trainees are motivated to use the system. They present an ongoing research that they are carrying out with county public health department steamline their training purpose. The motivational affordances theory has been used for a guide their design efforts. The game will be introduced into the public health organization workflow in modules that are in a sequential way. Thus the use of gamification can increase the user motivation and will be helpful in enjoyment of personnel involved.

Reid [4], described the concept of gamification with crowd sourcing technique that is used by the magazine named "inspire." They use this method for recruiting and training of believers. This is a virtual game that can be easily played by anyone. Author provides a customized crowd sourcing and gamification frameworks for "inspire." It can be used in security informatics applications to identify different participants. It can also be used in operational and training purpose.

Eleftheria and charikleia [5], proposed a technique that focuses on augmented reality (AR) and gamification for the establishment of an academic AR book. They proved that long- lasting training and arts education can be promoted through using the latest technologies and techniques that were extensively used in games. The approach of AR book can be applied to science subjects for children who come across the ages of 10-12 years. The AR book can be used to give a better understanding of the subject and will try to enhance the enjoyment in learning. This method can be used to create creativity and critical thinking. This method can also be applied to teaching purpose.

Saha et al. [6], analyze different image based captcha's by using some usability factors. GWAP (game with a purpose) approach has been used to analyze the usability factors. It is a method to collect the large amount of data in small time. They have designed a game "Captchino" for the analysis of usability. Today image based captcha's are more in use rather than text-based captcha's. Captcha's are used to thwart attacks by solving a puzzle before being accessed to service. These puzzles are called Captcha's.

Hall et al. [7], proposed a gamified frame of reference within a social network platform for the purpose to lower traditional entrance limitations for the well being data collection and to encourage continued usage. In this framework, participants can keep track or record the aspects of their well-being as a part of their normal social activities. Participants can view trends of their community. Well being games are means for supporting the design and management of larger institutions and communities.

Law et al. [8], designed a game layer in a sustainable mobile application. They discussed that how adding a game layers can be helpful in improving the basic activities of society. Badges based games are more useful for attracting users. Interactive mobile application

has designed with the principles of simplicity and convenience to change the way of people reporting road accidents cases. They just need to click the photo and touch on the screen for reporting the road accident case. They motivate users of mobile application by applying points, levels, and challenge to engage them. A game layer has been added to create fun and influence.

Dubois [9], proposes an approach that shows how self-organization can be used to model the introduction of game mechanics for motivating and simplifying the use of context aware user applications. Many features of modern video games can be abstracted by using self-organizing models. This feature can create a good sense of cooperation or competition to reach their goal. Same features of pleasant video games can be added to normal applications that can give the double advantage of speeding up the learning curve.

Azadegan and Riedal [10], developed a framework that is based on classification to know that how the serious games can be integrated into companies. Serious games are the games that are used to educate and for training purposes. To gain this aim the cases of games has been identified by different experts, conferences, events, and from developer companies. They identified that these games can be used in corporate training, for change management by gamification method. They have presented a case study of type of use in the paper.

Kroeze and Olivier [11], discussed how gamification can be used in the authentication process as a new approach for achieving usability and security. Security and usability always conflict with each other. The aim of security is to make the system difficult for attackers, but it can create a problem for the user. Mostly text-based passwords are used for the authentication purpose. But these passwords are difficult to remember. Thus the use of gamification in authentication purpose can convince users to act more securely.

Crowley et al. [12], proposed a framework of mobile community coverage that uses the social web and social gaming for enjoyable and sticky experience for users. They described the approach of community mobile coverage where people can report on the latest issues in their society. By using game mechanics in framework user engagement

can be gained through gamification. They described that by applying game architecture in framework, fast and specific service can be created that satisfies the user's goals.

Herzig and Ameling [13], proposed a platform for gamification and its integration into EIS. Gamification is used to increase user engagement, motivation and participation. This approach is best in enterprise information systems that mainly focuses on efficiency inspire of motivation and enjoyment of people. Prior the gamification is only used for customers. They have proposed an environment for the enterprise gamification.

And [14], describes the gamification as a real-world example. They have taken the example of book "Drive" of Daniel Pink." In this book, the author gives the details of the relationship between motivation and problem solving in different findings. Gamification is of AMP (autonomy, mastery, purpose) behavior. Thus, it can be used to solve the problems like out of box problems.

Neeli [15], proposed a technique to increase engagement of employees in BPO industry using gamification. They used a gamification method to encourage employees using gamified environment that produces interest in the task. The today BPO industry is facing different challenges like employee motivation. To overcome this problem engagement of employees is discussed as the most important step. It can be achieved by gamification.

Depura and Garg [16], proposed a method of online gamification for newly hired Onboarding. They study the problems faced by HR to hire new employees. They have designed software to overcome the problems faced by HR. Using interactive game mechanics can set up the engagement of the learner and can enhance their brand. It can result in higher productivity.

Lee and Doh [17], proposed a gameful design for the video lecturing system. Today mostly, students learn in the digital educational environment. Video lectures are taking as a key component of an E - learning system. But in a video lecture system, there is a problem regarding sustainability. Thus to motivate the users they focused on enhancing emotional engagement through the use of game mechanics.

Vieira et al. [18], investigates how people can be motivated by using gamification along with Collaborative riding as a complementary alternative to public transportation. They conduct two exploratory studies with the users of transportation to understand the subject and actual problem faced by the passengers. They have conducted a questionnaire for the Brazilian people and field study for two different groups. After these studies, they provide the results that they got.

Bierre [19], implemented an initial game design course, i.e. The Multiplayer Classroom. Then they do a survey and find that there is a positive result and also some students want some changes in the game. This paper presents the problems encountered, and suggestions provided by some students. They mentioned this game became successful and meets its objectives.

Concilio and Pacheco [20], discussed that a Learning Management System provides interactive resources and more interesting way for teaching and learning. In this paper, they proposed e- learning environment for improving emotional engagement by using game and experience design. They describe the resources that can be used for enhancing teaching and learning. They told that games are rich and efficient tools for increasing learning and teaching system.

Fujikawa and Min [21], designed an environment that will help researchers to find information from routine user using game. They find that the game they have developed was successful in attracting users who played the game. They discussed that it has been proved that game has a large effect on user engagement. They realized that the user who played games for a long time could understand complicated problems. The paper shows that if the game is well designed, then it will be very easy to train to general users who can be specialized in solving problems.

Gordillo et. al [22], proposed a generic method for creating a new way of visiting the city in spite of seeing it as a place of tourism they were considering it as a place of learning in which educational resources are used for end users. This paper presents the effect of using gamification, learning and tourism in conjunction in model design. They have

proven that the city can be used as an effective place of learning. They have performed different activities in the city as a learning platform in combination with gamification.

Gehringer and Peddycord [23], provided an approach online gaming where the students can gain experience points instead of percentage based grading. Students can gain experience points for each new action, and their marks will automatically be increased towards desired goals. The students appreciated the ability to earn additional points by performing extra activities.

Latoza et. al [24], used the gamification concepts in the process of crowd development. The work is divided into four micro tasks, which are small, self-descriptive, and of modular form. Crowd development helps to reduce the software development costs, increased the productivity of programmers and makes programming more enjoyable and fun. Points have been used in completing each micro task.

Smith [25], discussed that shifts in different industries or workplace will frame the perspective of the work. Societal and technological advancement in these work places will trend to more usage of game mechanics. Several Microsoft companies have started using game mechanics for enhancing the software engineering processes. Applying of game mechanics has led to significant productivity improvements. Thus games are the important component of any workplace in the future.

Moccozet et. al [26], created a graphical user interface to inspire training by associate sharing and impressible feedback. They proposed criteria for the rating of aggregation work by gamification components. The rating of the students can be shifted to the engagement to share and engage in the learning society. The resulting environment motivates students to take part and collaborate.

2.2 Analysis of Literature Review

2.2.1 Games for Teaching/Learning

From the review of literature, we analyzed that gamification of learning and teaching practices gives the better result. It can be seen that gamification is very helpful for engaging the students. This will give the positive results. It can be seen that it has become important for making learning enjoyable. Basic information admits that learners advised badges as a powerful positive share to make them feeling more committed and motivated to complete the tutorial [6]. It can be seen that the games were perceived as useful for introducing some difficult topics and for teaching operational procedures [17]. By using gamification in learning learner can easily understand the underlying theories [18]. Rughinis redefine gamification in learning as 'simple game play to support productive interaction for expected types of learners and instructors [22]. Thus gamification in learning is exploitive [22].

Table 2.1 Mechanics used for learning and teaching

[17]	Feedback, points
[32]	Badges,
[12]	Feedback, points, badges
[33]	Feedback
[34]	Feedback, dashboard, points, badges

2.2.2 Serious Games

Serious Games are games that educate, train and inform using entertainment principles [7]. These games have been employed by different domains like training, education, health, public policies [7]. Serious games are games used for reasons other than entertainment [15]. These games include different categories, educational games, advertising games, political games and training games. The psychological benefits of games include better motivation and less stress. It also has been used in military services for a long time to train the strategic skills. One main example where serious games has been used that it is used for gamifying the authentication process [15]. Here points based game gas being used.

2.2.3 Mechanics that are used as Motivational affordances in Games

In table 2, we can see that large amount of game mechanics is used for creating motivation among the students, employees, trainees, etc. All these mechanics provides positive results. The mechanics that are used for the motivational purpose are shown in table below.

Table 2.2 Mechanics used for the motivational purposes.

Factors	Paper
Points	[7],[17],[2],[12],[12],[35],[11],[26],[13],[24],[23],[15],[36],[34],[37]
Leader boards	[36], [16], [13], [37],[15],
Badges	[32],[2], [12],[25],[13],[21], [34],[11]
Levels	[7],[15],
Feedback	[17],[12],[35],[36],[13],[3],[4],[15],[33],[19],[34],
Rewards	[7],[32],[31],[36], [23],[26],[4]
Progress bar	[36]
Challenge	[16], [13]

2.2.4 Where Gamification has been used

Gamification can be used where there is a need to engage or motivate the users. There are different areas where gamification has been used for engaging the user. Table 2.3 below display the areas where it has been used.

Table 2.3 Areas where gamification has been used

Areas	Paper
Well being measures	[7]
Learning/teaching	[17],[32],[33],[1],[22],[38] [33],[20],[36],[34]
Security	[11],[6],
Online community	[2]
For algorithm	[21]
Work/training	[16],[13],[3],[15]
Sports	[39]
Recycle bin	[31]

2.3 Summary

The previous research work shows that gamification can be used as the main tool for engaging the users where there is a need to engage them. Gameful design has the possibility to enhance emotional engagement and change learning attitudes [2]. Different game logistics like points, levels, badges, feedback can be used as motivational affordances. From the studied literature, we can see that there is a positive result in many

areas where gamification has been used. Serious games are also very productive in many areas like training, education, health, etc.

2.4 Plan of Thesis

This thesis follows a following structure to complete the research work (fig.2.1).

Chapter 1 provides the introduction of this document. Along this Problem statement, purpose and objectives of the thesis are also provided.

Chapter 2 provides the Literature Review and Analysis of Literature review

Chapter 3 describes the architectural designing and implementation of the proposed gamified environment.

Chapter 4 elaborates the results and performance evaluation of the gamified learning environment.

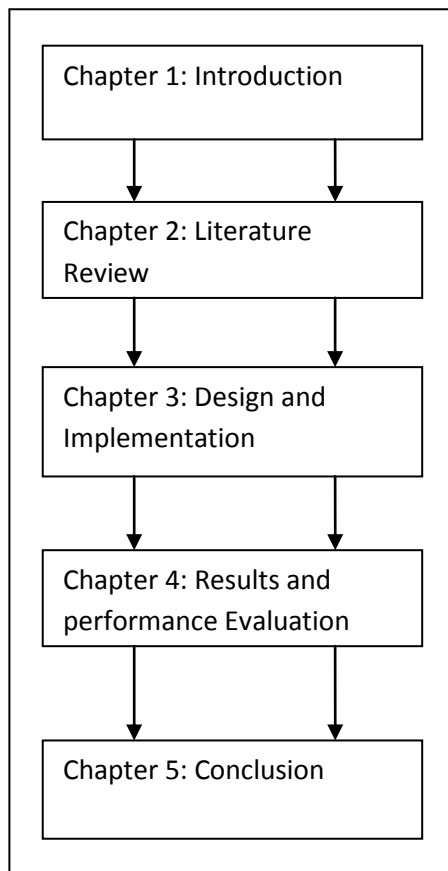Chapter 5 provides the final conclusion of the thesis.

```
┌─────────────────────────────────┐
│  ┌───────────────────────────┐  │
│  │ Chapter 1: Introduction   │  │        **Figure 2.1 Plan of Thesis**
│  └───────────────────────────┘  │
│         │           │           │
│  ┌───────────────────────────┐  │
│  │ Chapter 2: Literature     │  │
│  │ Review                    │  │
│  └───────────────────────────┘  │
│         │           │           │
│  ┌───────────────────────────┐  │
│  │ Chapter 3: Design and     │  │
│  │ Implementation            │  │
│  └───────────────────────────┘  │
│         │           │           │
│  ┌───────────────────────────┐  │
│  │ Chapter 4: Results and    │  │
│  │ performance Evaluation    │  │
│  └───────────────────────────┘  │
│         │           │           │
│  ┌───────────────────────────┐  │
│  │ Chapter 5: Conclusion     │  │
│  └───────────────────────────┘  │
└─────────────────────────────────┘
```

Figure 2.1 Plan of Thesis

Chapter 3

Design and Implementation

The gamified application has been designed and implemented in an interactive way for improving the learning process of Data Structure. In this application, the main concepts of Data Structure have been used. Along with the basic concepts, comparisons of different sorting algorithms along with their time and space complexity are also included. The application is divided into four levels. Initially, level 1 is enabled to interact and level 2, level 3 and level 4 be will will be disabled. If the user completes level 1 at a desired time, then level 2 will be enabled otherwise it will remain disabled. Then after completing level 2 in required time the user will be able to interact with the next level and so on. The general flow of the user in the application is delineated in figure 3.1.

For the development of application, Java's programming with Android Development Tool (ADT) has been used. The front end of the application has been designed by using Extensible Mark-up Language (XML). The main implementation of the gamified application is based on the data flow diagrams that are discussed below. The different modules that are included in the application are shown in the data flow diagrams in section 3.1.
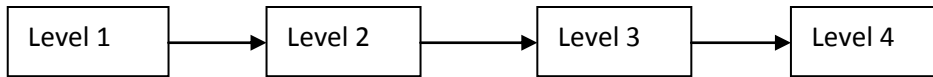
```
┌─────────┐      ┌─────────┐      ┌─────────┐      ┌─────────┐
│ Level 1 │ ───▶ │ Level 2 │ ───▶ │ Level 3 │ ───▶ │ Level 4 │
└─────────┘      └─────────┘      └─────────┘      └─────────┘
```

Figure 3.1: General flow of user in application

3.1 Workflow Diagram

The implementation of the application is based on the workflow diagrams. These workflow diagrams gives information about the framework for the implementation of the gamified application and also gives information that how the user will interact with the application. There are five workflow diagrams that are included in this section i.e. workflow diagram of the entire application, workflow diagram of Array activity, workflow diagram of Stack activity, workflow diagram of Queue Activity and workflow diagram of Binary tree activity.

3.1.1 Workflow Diagram of Play and Learn DS Application

The workflow diagram of the play and learn DS application is shown in figure 3.2. In the workflow diagram, we can see that application consists of basic concepts of data structure like Array, Stack, Queue and Binary Trees having different levels from level 1 to level 4. Initially, all the levels are disabled except level 1. All levels have different activities that the user has to perform and understand the main concepts of Data Structure. Timer has been used in all the activities. The user has to complete the activity in a certain time to enable the next level.
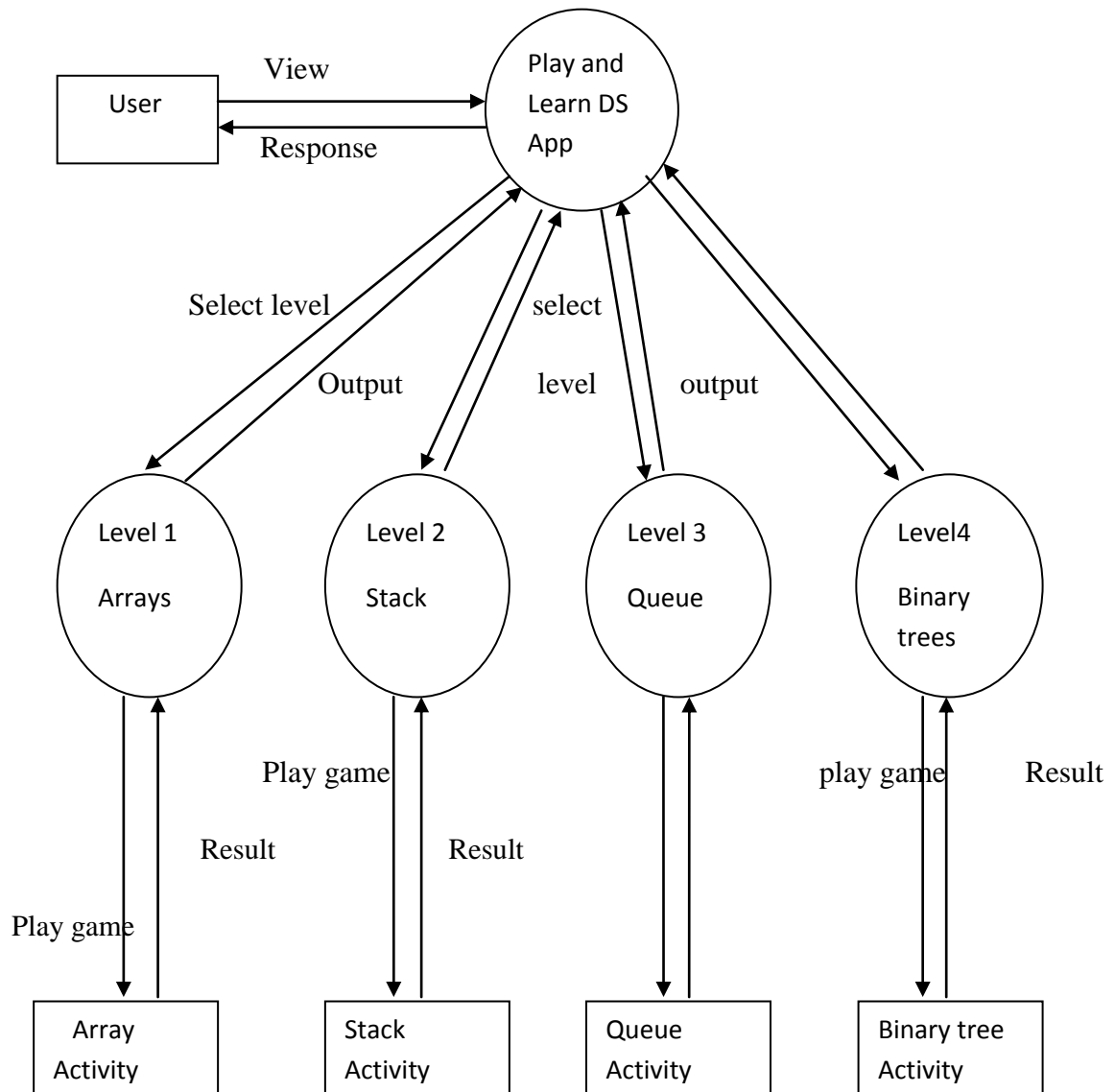
Figure 3.2: Work Flow Diagram of Play and Learn DS Application

According to the figure 3.2, at the start user can see four levels in the app. Initially user can select level 1 only; all the other levels are disabled. Only after completing level one user can proceed to the next level. After selecting the particular level user will be able to perform an activity in that level.
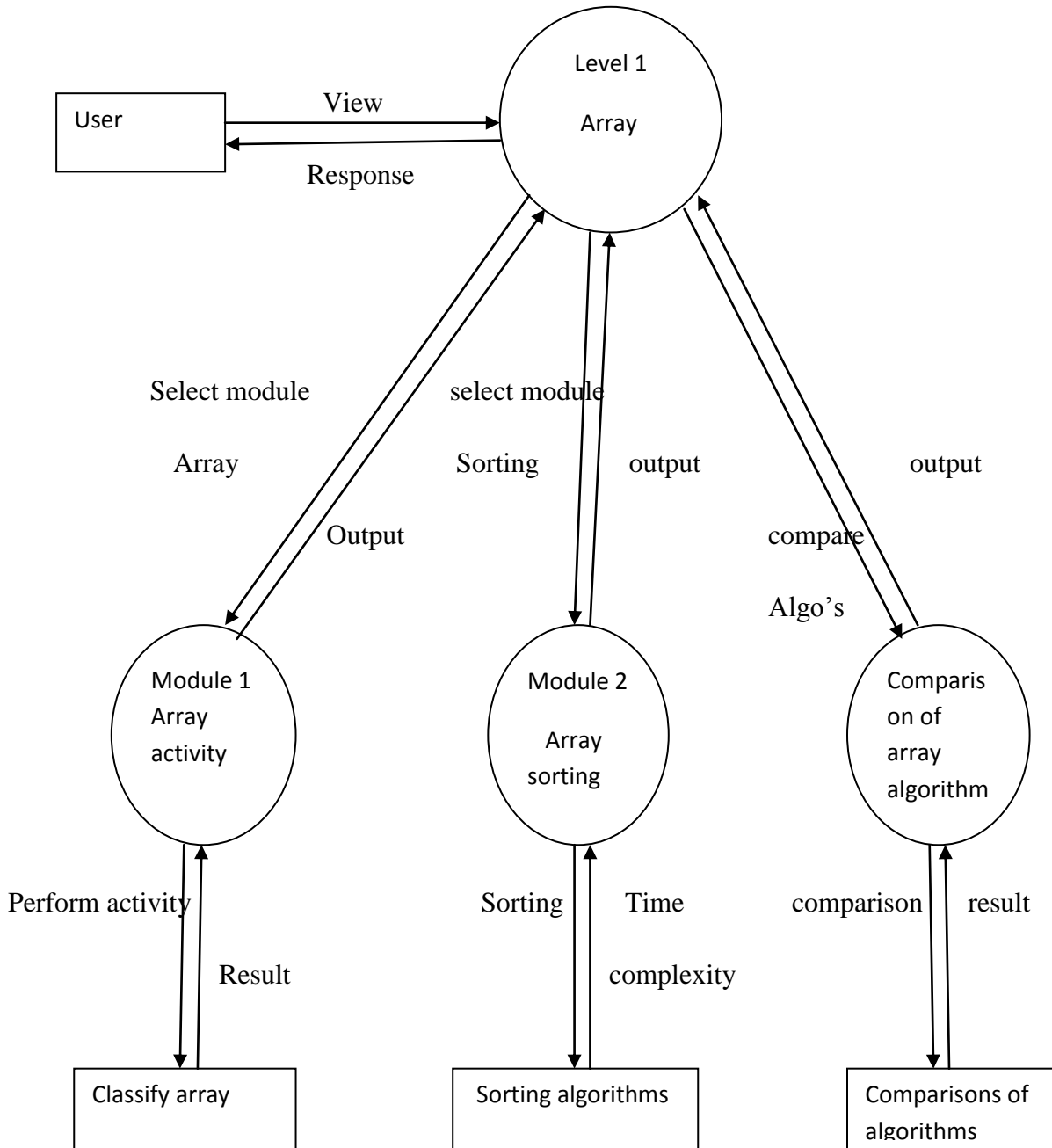
3.1.2 Work Flow Diagram of Array Activity

Figure 3.3 Work Flow Diagram of Level 1(Array)

As we can see in the above workflow diagram of Level 1, which contains the concept of an array, is divided into further three modules, i.e. Module 1, Module 2, and Module 3. In Module, 1 user will see that there is an activity of array classification, in Module 2, there is an activity analogue to the sorting algorithms and in Module 3 comparability of sorting algorithms will be there based on time complexity of different algorithms.

3.1.3 Work Flow Diagram of Stack Concept
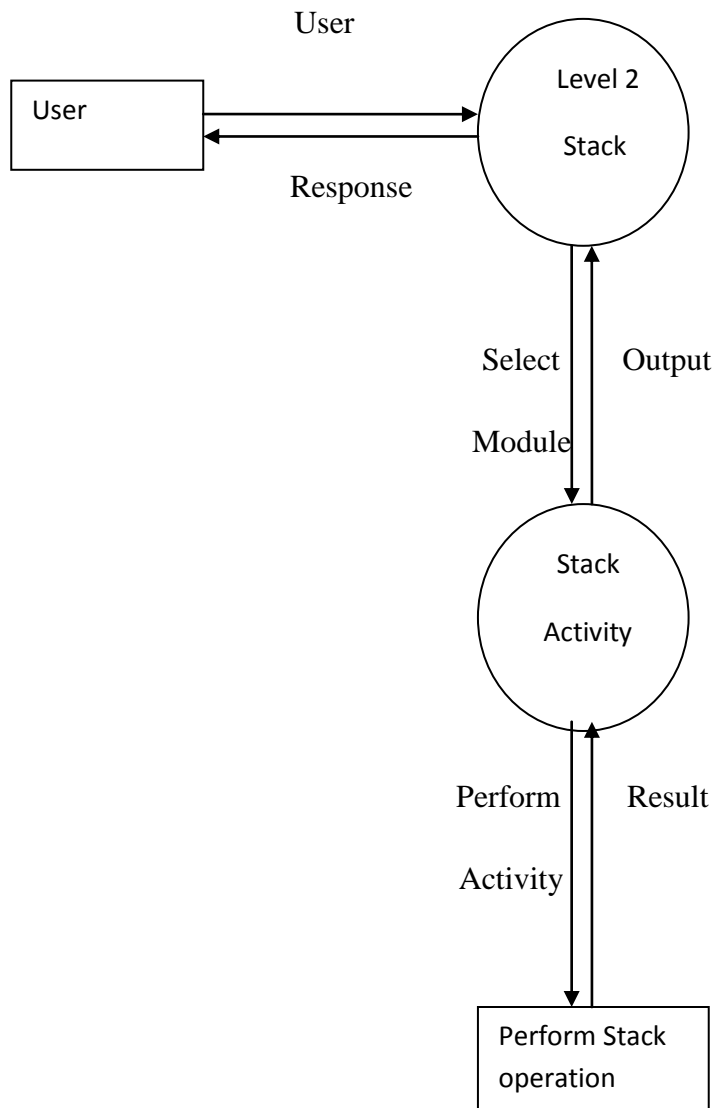
Figure 3.4 Work Flow Diagram of Level 2 (Stack)

In the above figure 3.4, we can see the flow of stack activity. Initially, level 2 is disabled. It can be enabled only after completing the level 1 which contains an array operation.

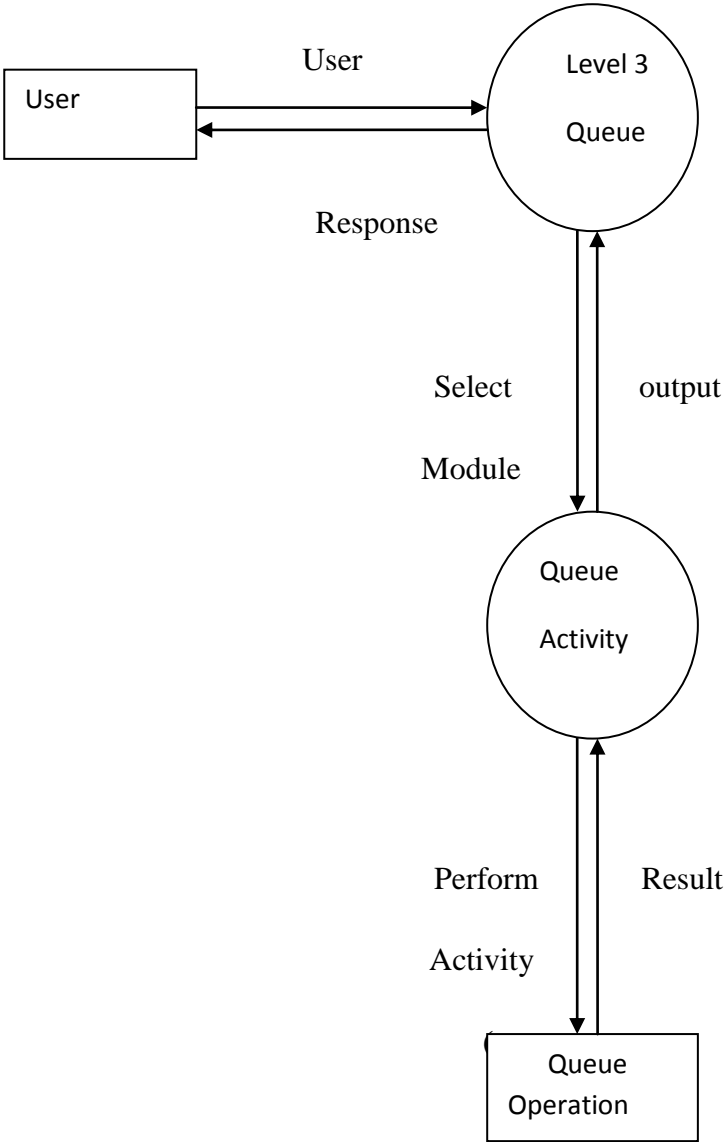**3.1.4 Work Flow Diagram of Queue concept**

Figure 3.5 Work Flow Diagram of Level 3 (Queue)

In figure 3.5, we can see the flow of the queue activity. Initially, this activity was disabled, after completing level 2 this activity will be enabled. The user will select the queue module and will start performing activity. The user has to complete this activity in a required time to enable the next activity.
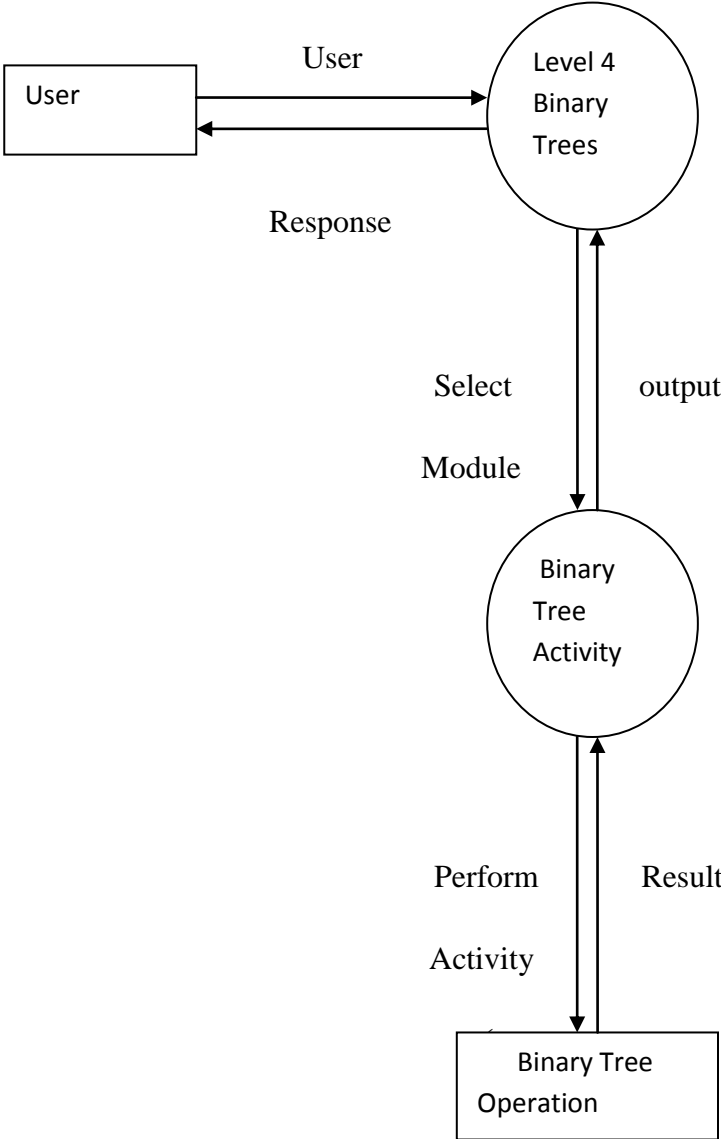
3.1.5 Work Flow Diagram of Binary tree concept

Figure 3.6 Work Flow Diagram of Level 4 (Binary Tree)

In figure 3.6 of workflow diagram of Binary Tree user can see the flow of the activity of Binary Tree. This level will enable after completing the Level 3. Level 4 is the last level of the application. On completing Level 4 users will come to an end of the application Play and Learn DS.

3.2 Implementation of the Application

The design of the Play and Learn DS application that is shown in the section 2.1 in the form of workflow diagram has been implemented by developing the application with the help of Extensible Mark-up Language (XML), which is used for the interface designing of different levels and activities and Java Programming Language has been used with Android Development Tool (ADT) for the implementation of the application. So that it can also be used on an android phone.

The flow of user in application has been discussed previously in this chapter in figure 3.1. The application consists of home page showing different levels like Level 1 (Array), Level 2 (Stack), Level 3 (Queue), and Level 4 (Binary Tree). Only Level 1 will be enabled, and all other levels will be disabled initially. Other levels will be enabled only after completing the previous levels. Level 1 has three subparts to perform different functions. The working of application is elaborated in next part 3.3 through different screen shots. Working of the home screen, array activity, stack activity, queue activity, and binary tree activity is described through screen shots.

3.3 Screen casts of Play and Learn Application

In this section screen grabs of different operations and activities of the application has been provided to show that how application will work. Figure 3.7 provides the screen grab of home screen.

Figure 3.7 Home Screen of Play and Learn DS Application

Figure 3.7 shows the employment of the workflow diagram shown in figure 3.2, which represents the home screen of the application. There are four buttons, which show the levels of the application. The four levels are, Level 1 (Array), Level 2 (Stack), Level 3 (Queue), and Level 4 (binary Tree). It can be seen that in the home screen, level 1 is enabled, but all the other levels are disabled. Here lock has been used to show which level is enabled and, which is disabled. Open lock will show that level is enabled and closed lock will show that level is disabled. Locked level will be enabled after completing the previous level at a desired time. Here lock will show progression of the user.

Figure 3.8 Definition of array

On selecting the Level 1 (Array), Definition of the array will be there to understand the concept. It can be seen in the above figure 3.8. Another button can be seen on the screen, i.e. "let's play with an array" after clicking this button, user will see three modules in next page on the screen. The screen cast in following figure 3.9 will show these concepts.

On this page, there will be three modules, i.e. Array Sorting, Comparing Array Sorting Algorithms and classify array. In addition, there is a description of these modules. In module 1, there will be an activity of classifying the arrays which will depend on a timer. Level 2 (Stack) will be enabled after completing this level in a particular time. Then in module two sorting of different array algorithms have been shown with its time and space complexity in an interactive way and in module three comparisons of different algorithms based on time complexity have been shown. This will show that which algorithm will take more time to perform sorting of an array. The screen cast is shown below in figure 3.9.
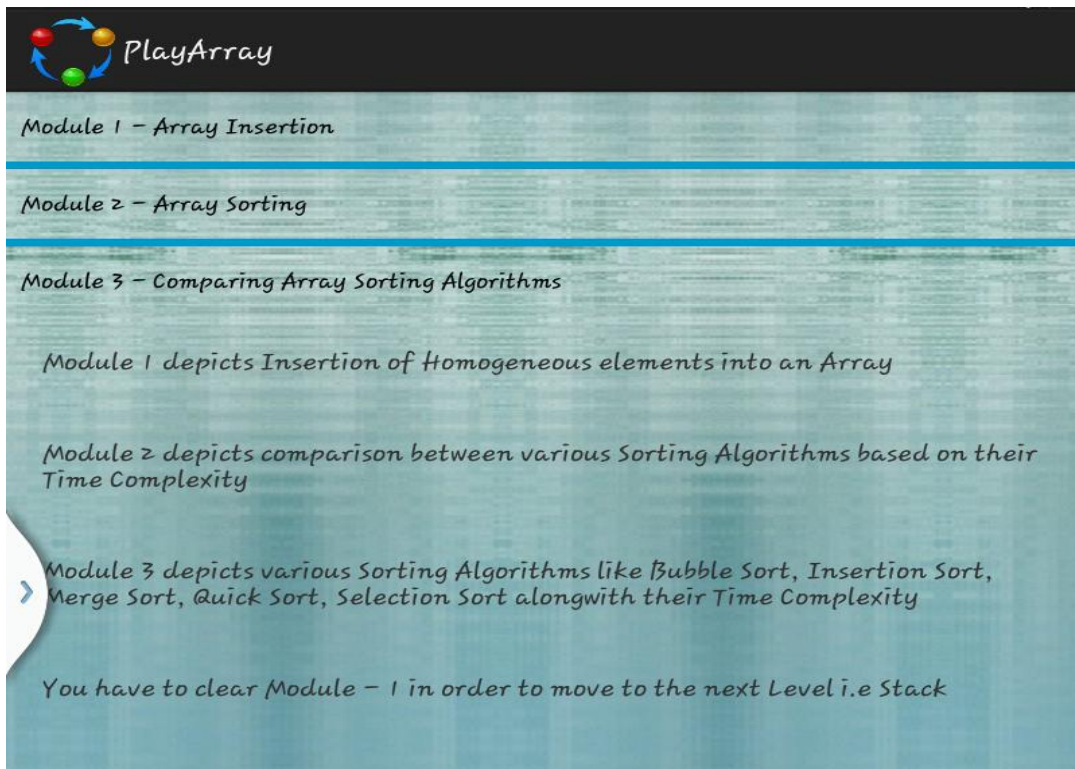
Figure 3.9 Modules of Level 1 (Array)

On selecting Module 1, there will be a new screen which will show the activity of classifying arrays. It has been shown in figure 3.10 below. User has to complete this activity in 15 seconds only. After completing this task on time, there will be a dialog box of giving "AWESOME" with smiley on completing the task in a time. If the user does not complete the task in an allocated time, then there will be a dialog box which will say "sorry." The screen grabs of these dialog boxes are shown in figure 3.11, figure 3.12 and figure 3.13. As in the figure 3.10 there are squares of two colours, i.e. blue and green. User has to drag and drop these squares in the pine in 22 seconds. User can insert only identical color of squares in pine after its initialization. This will clear that after the initialization of an array, we can insert only same type of elements.
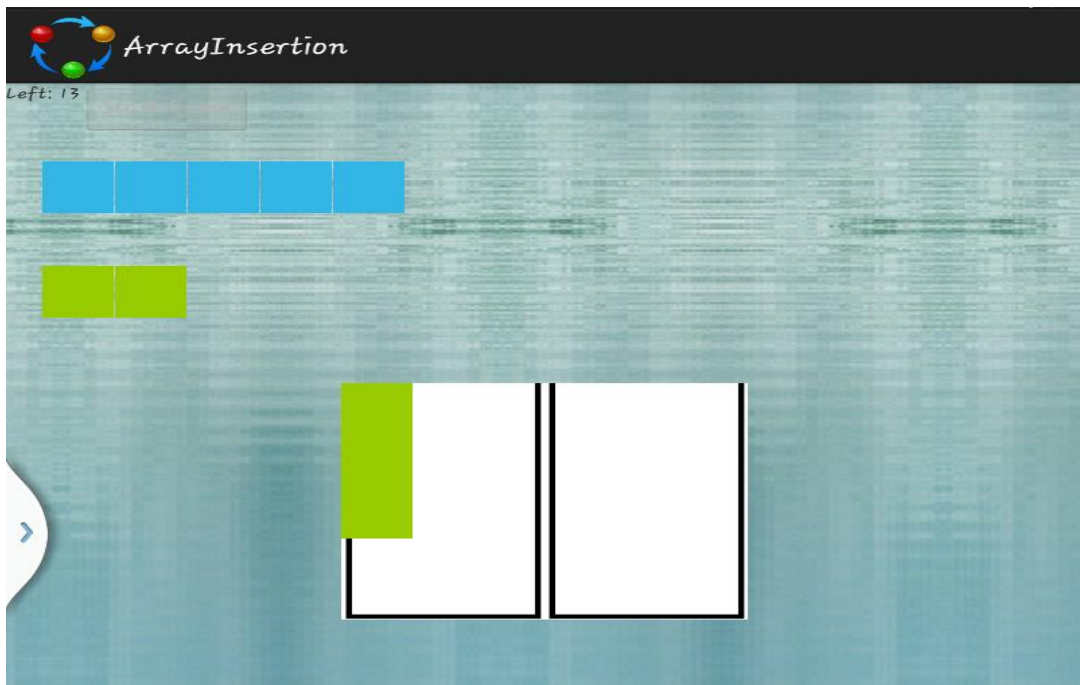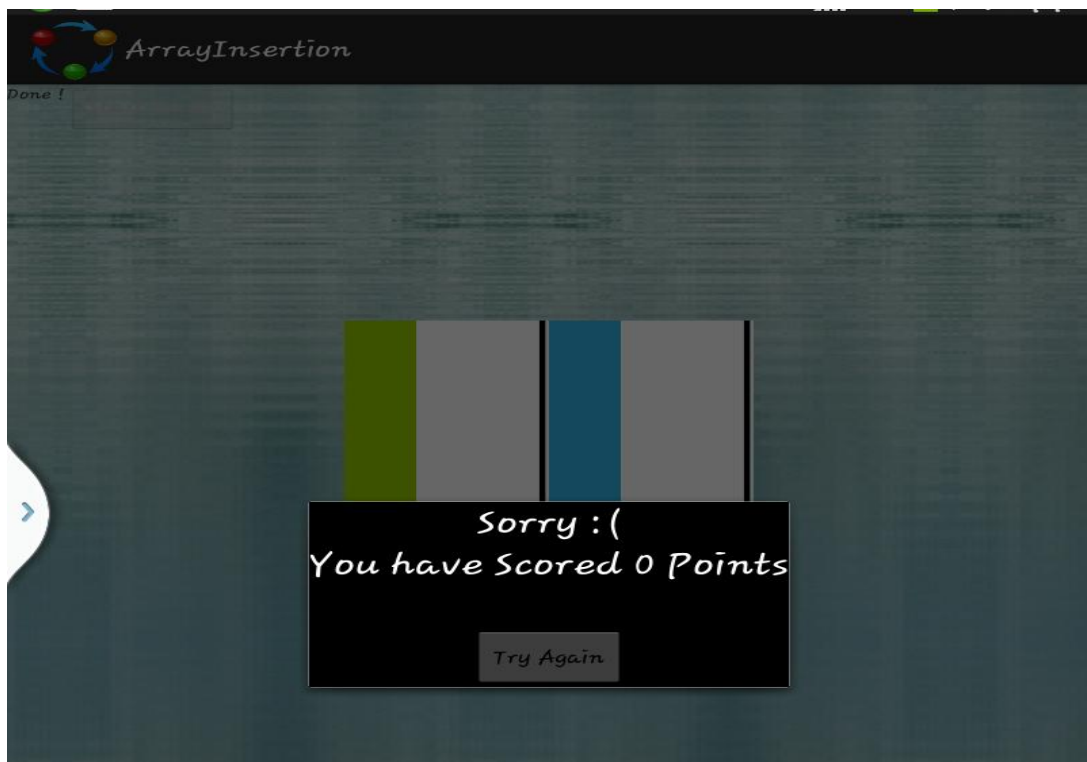
Figure 3.10 Array Insertion

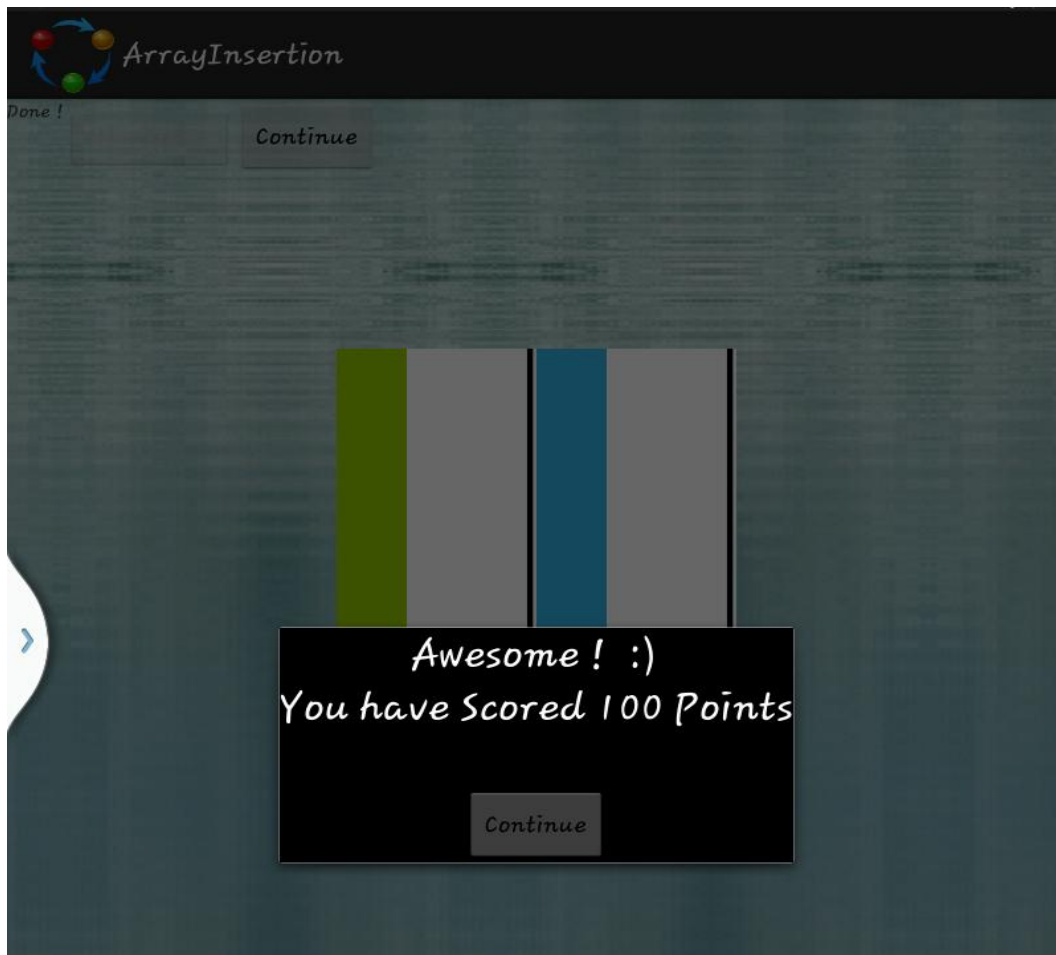**Figure 3.11 Dialog Box on not completing task**

Figure 3.12 Dialog Box on completing Task

After completing this level user will press on "continue" button to select the next module of Array. Then user will see that there is a module 2 which shows the working of different sorting algorithms along with their time complexity and space complexity. The screen grab of this module is shown in figure 3.13 and figure 3.14. After this, there is a Module 3 in which user can see the comparison of different algorithms on the base of time complexity. The screen grab of comparison is shown in figure 3.15. The sorting algorithms that are included in the module 2 and module 3 are bubble sort, Insertion sort, Merge sort, quick sort, and Selection sort. User can select any algorithm for understanding the working from the Drop-Down index which is shown in figure 3.16. After module three operations of level 1 will come to an end. Unlocking of level 2 is based on module 1 only.
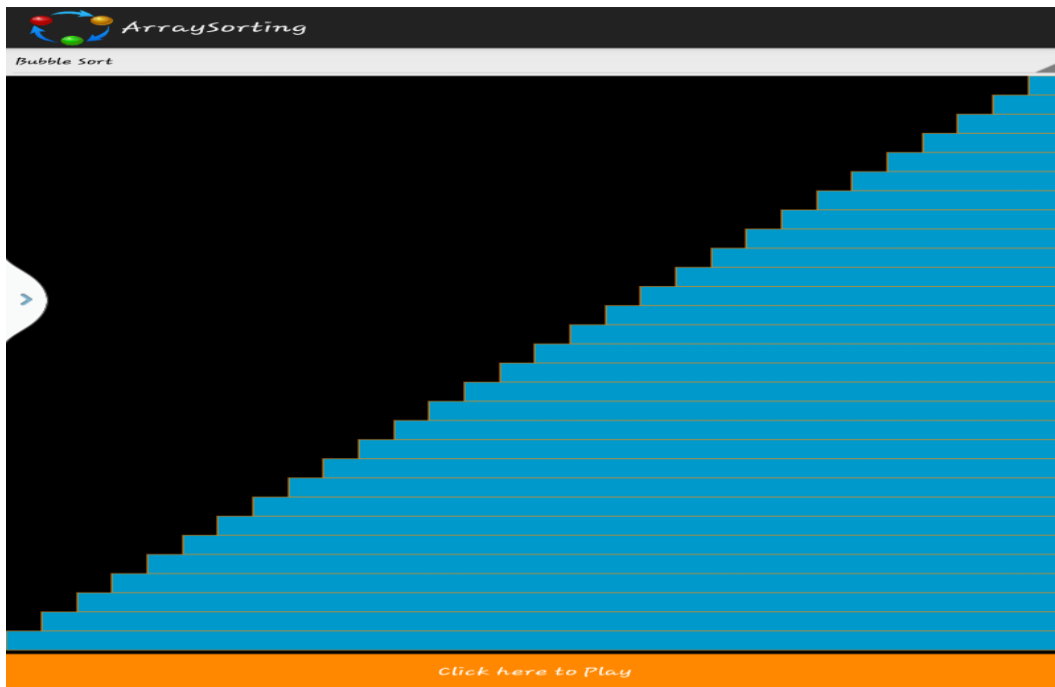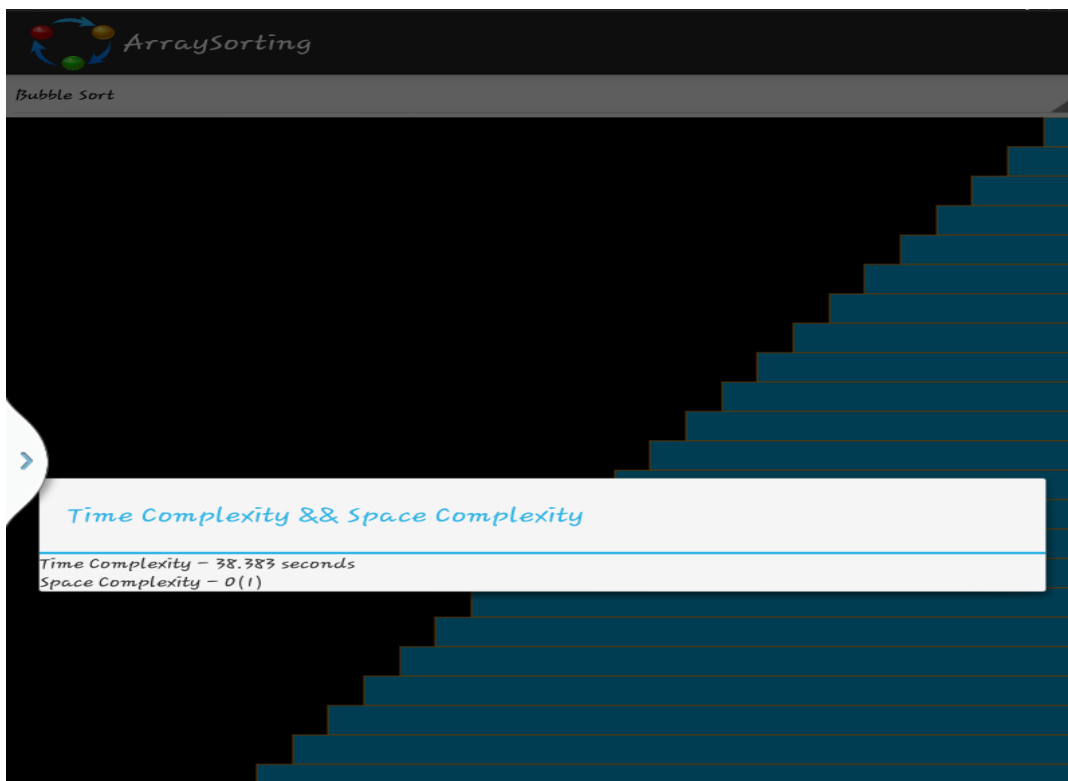
Figure 3.13 Working of Bubble Sort Algorithm

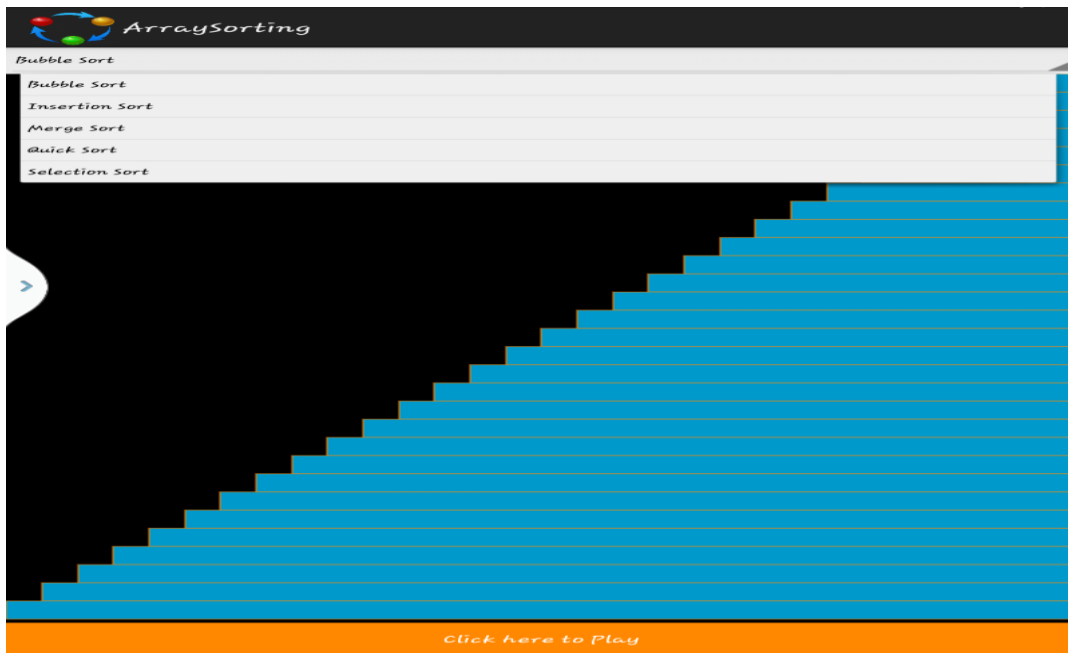
Figure 3.14 Time and Space Complexity of Bubble Sort Algorithm

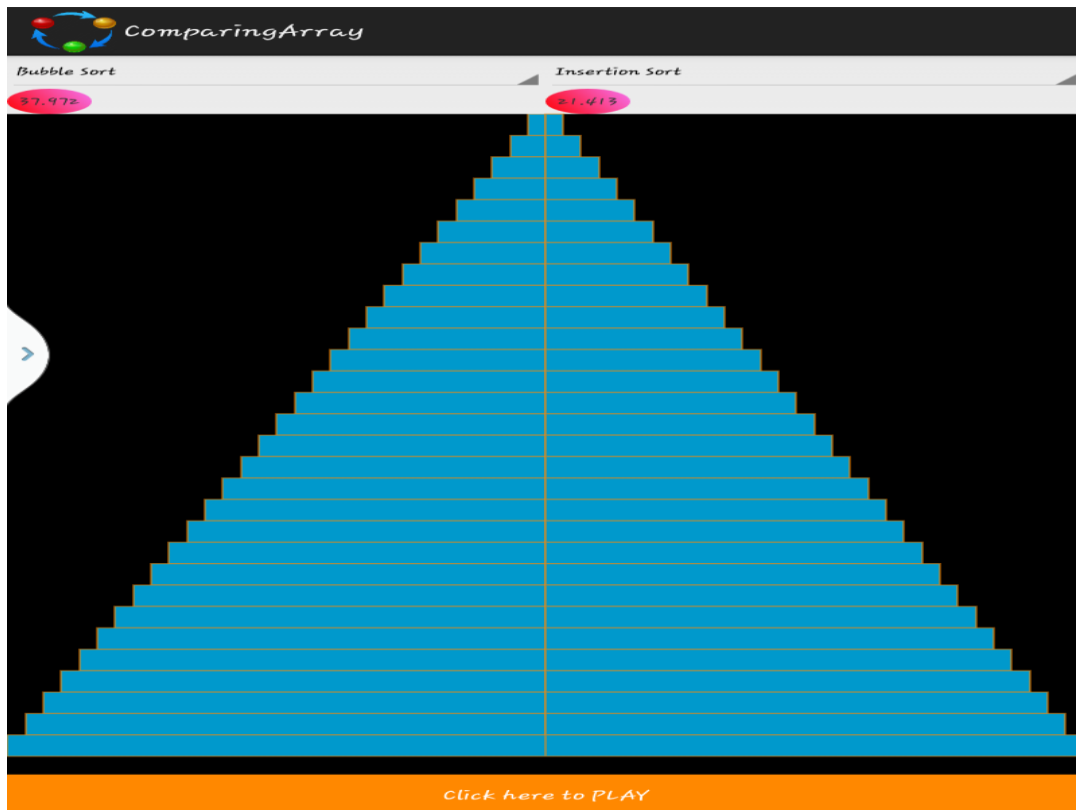**Figure 3.15 Drop down List of Sorting Algorithms**

Figure 3.16 Comparison of Sorting Algorithms

After this main screen of the home page will be opened, and here user can see that level 2 (Stack) has been enabled to perform the task. The screen grab of the home page after completing level 1 (Array) is illustrated in figure 3.17. Then to start level two, users have to press button showing level 2. After pressing this button, screen with the definition of Stack will be opened; this is delineated in figure 3.18.

Figure 3.17 Home Screen after completing level 1 (Array)

Initially, level 2 (Stack) was disabled and after completing level 1 (Array) level 2 is enabled. Opened lock in the screen display that level 2 (Stack) is enabled. Still next levels are disabled. Now user can perform an activity for Stack concept.

After the home screen, there is a definition of stack for the user to understand the concept i.e. the stack uses the LIFO (Last in First Out) principle. After this, there is an activity of Stack, which is based on this principle. After start playing with Stack, there will be an empty stack on the screen. There are two buttons, i.e. PUSH and POP on the screen. User can push the values in Stack after pressing PUSH button. The action of push should be complete in 10 seconds after pressing Start Game button.
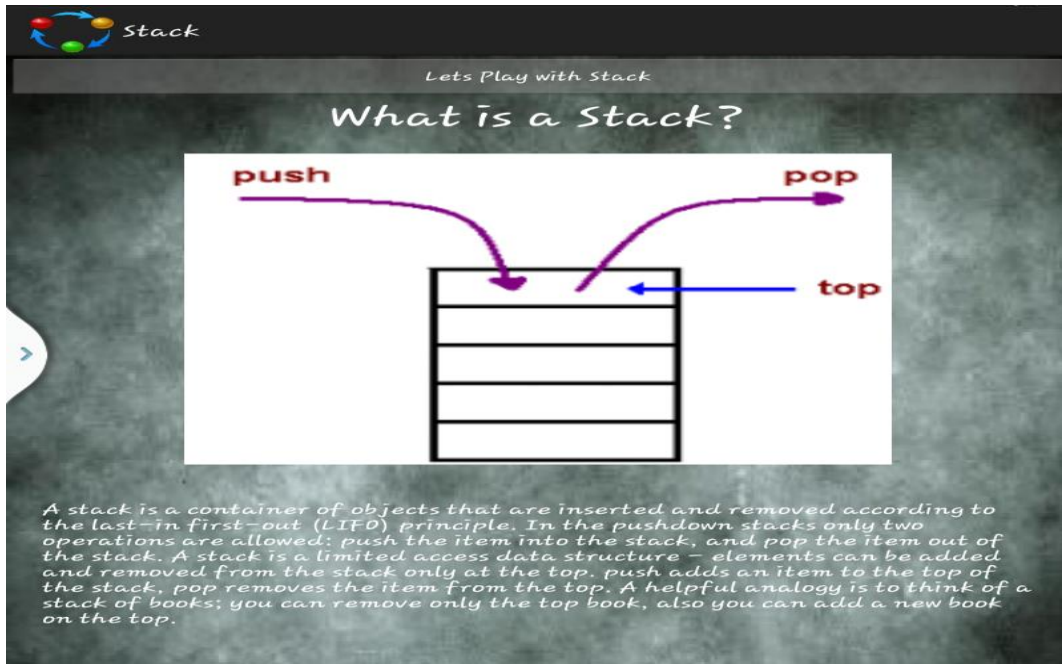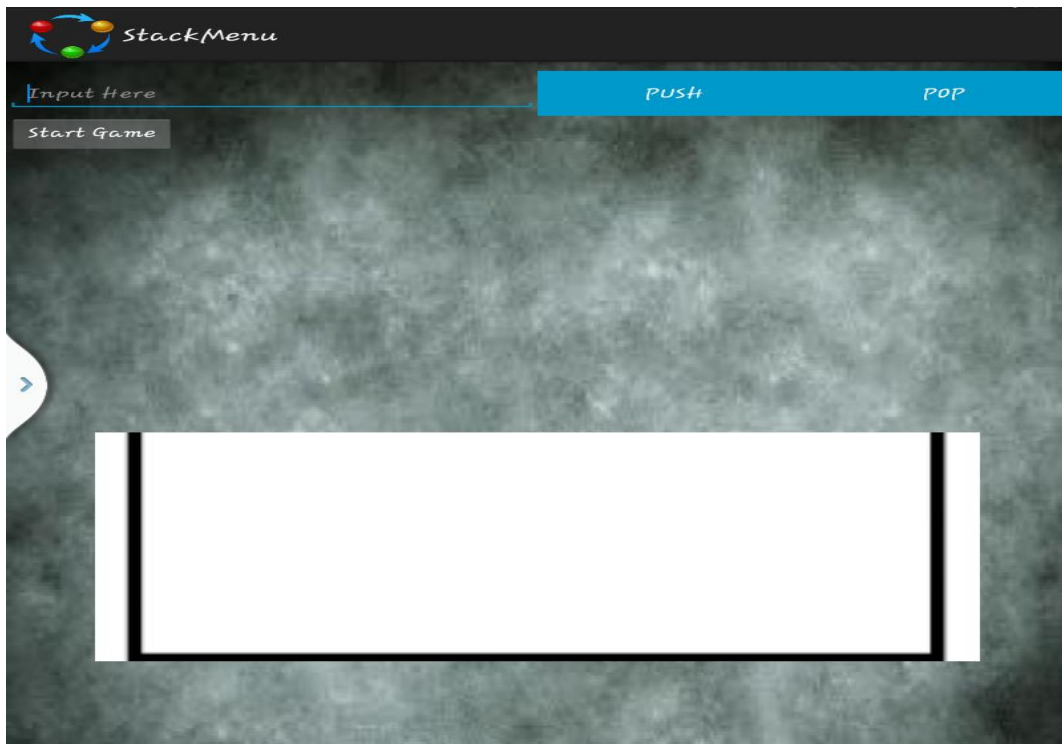
Figure 3.18 Definition of Stack

Figure 3.19 Empty Stack

As in figure 3.19 it can be seen that stack is empty initially. Figure 3.20 display the stack after the insertion of values in it. After completing the insertion of values in stack Dialog box of showing "AWESOME! You Have Scored 100 Points" with smiley will be there that are delineated in figure 3.12. Similarly if the task does not completes in required time, then Dialog Box showing "SORRY! You have scored 0 points" with sad emotion will be there. After completing the task user can also POP the values to understand the working of POP operation in Stack.

Figure 3.20 Stack after PUSH operation
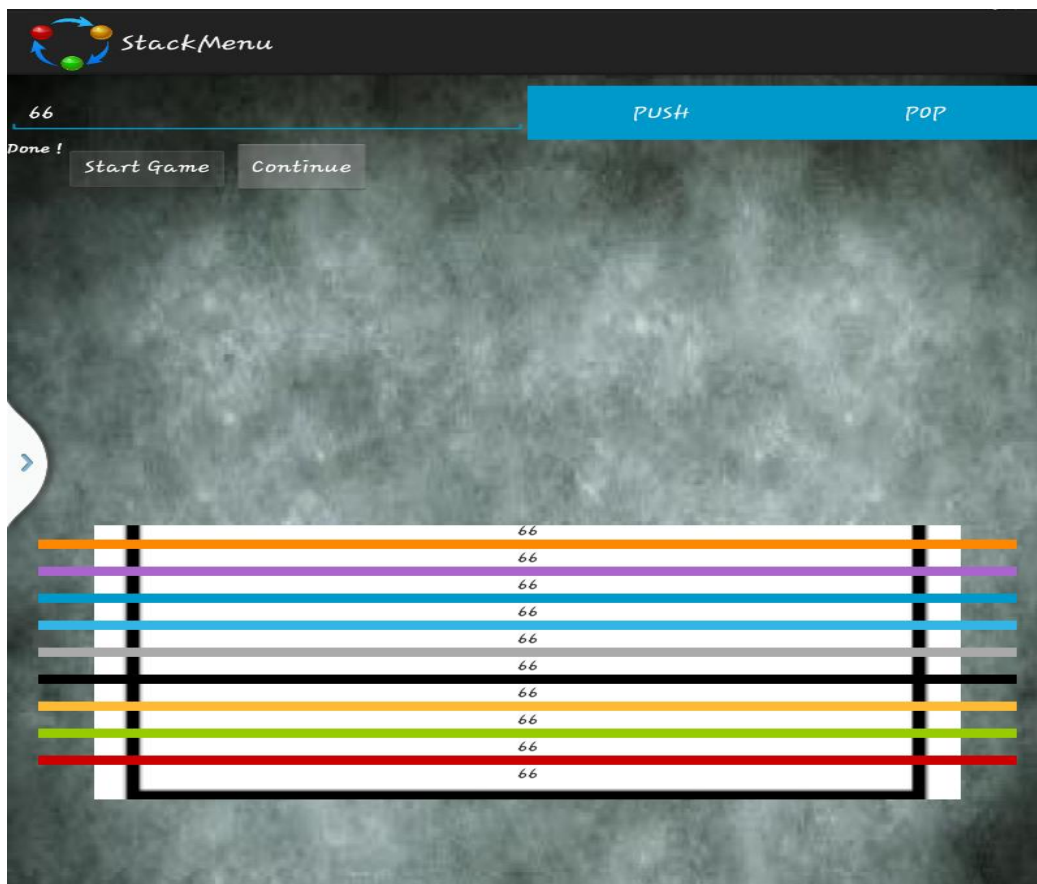
After completing the insertion of values in stack in required time level 2 will come to an end. Then user also can try with POP Button and to understand how it works after the insertion. The screen shot of the working of POP Button is shown in figure 3.21. Here user can clear the principle of POP button. POP button will delete the values firstly, which was inserted in last.
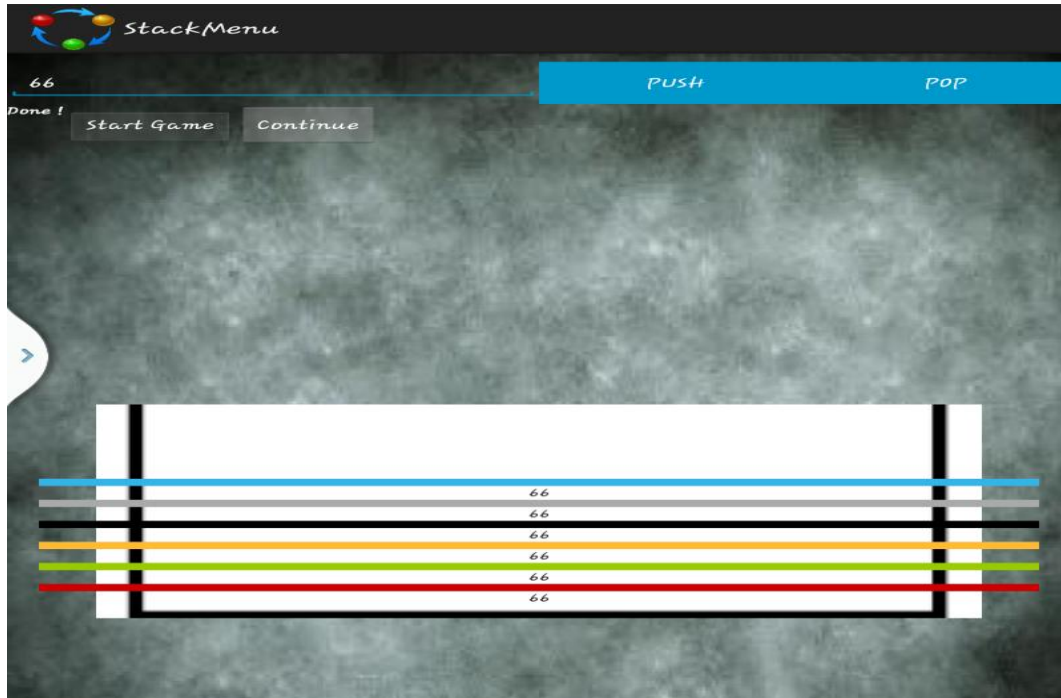
Figure 3.21 Working of POP Button

After popping values from stack user can press "Continue" Button for performing in the next level. After pressing "Continue" Button, there will be a home screen showing that the level 3(Queue) is enabled now to perform activity. The screen grab of the home screen is shown in figure 3.22. Here in Home Page user can see that the Lock is opened now. Now user can press on a Level 3 (Queue) button to enter it. After entering there will be a screen of definition of Queue, which will clear the working of Queue operation. Queue works on FIFO principle, which is mentioned in the definition of the queue. The screen cast of the Definition of Queue is delineated in figure 3.23. On the page of Definition of the queue, there is a button "Let's Play with Queue" and after pressing on this button user can enter the main activity of Queue. Then new Page will be opened, which is delineated in figure 3.24.

Figure 3.22 Home Screen after completing level 2

Figure 3.23 Definition of Queue
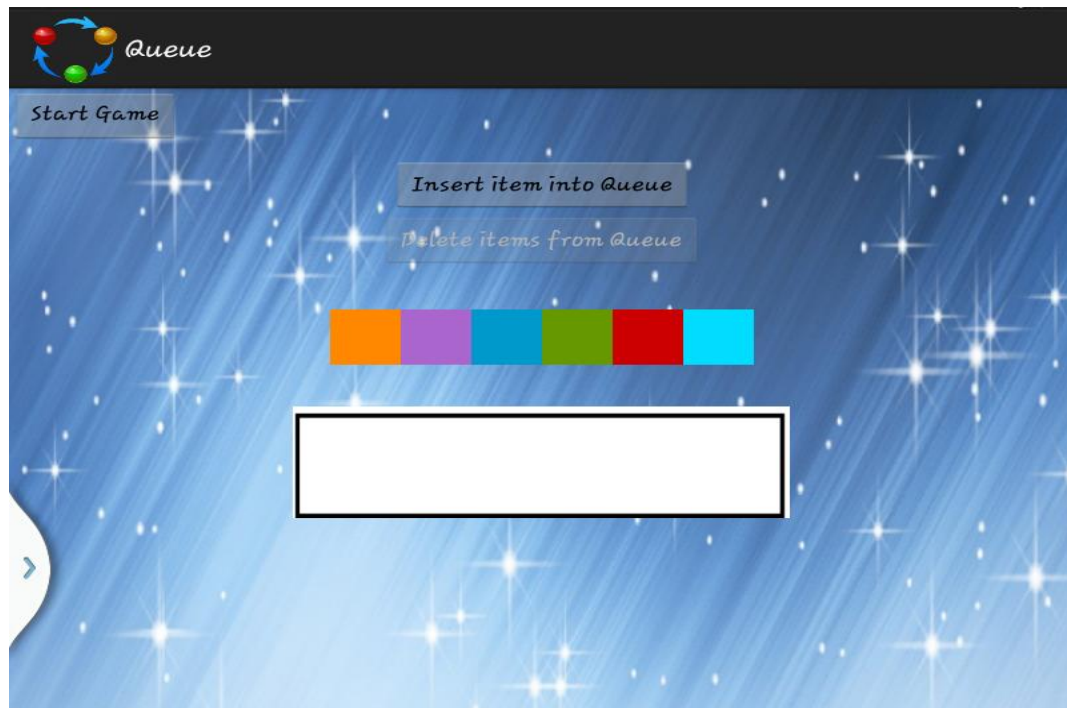
Figure 3.24 Queue before insertion

As in the figure 3.24 user can see that initially queue is empty where the user has to insert squares. Above the queue, there are squares of different colours on the screen. To start the activity user has to click on "Start Game" Button. After clicking on this button timer will be started, and user has to drag and drop the squares in the queue in 15 seconds to complete the task. If the user does not complete a task in required time, then Dialog Box of "Sorry!" with sad emotion will appear on the screen. And if the task completes in 15 seconds dialog box of "Awesome!" with smiley will appear on the screen. Both these dialog boxes are already delineated in figure 3.11 and 3.12. The screen shot after the insertion of squares in a queue is delineated figure 3.25. After completing the task user also can dequeue the squares from the queue to understand the concept principle that queue will insert items from rear and dequeue it from the front. The screen cast of dequeue operation is given in figure 3.26. Then user can press "continue" button to go the next level of the binary trees.
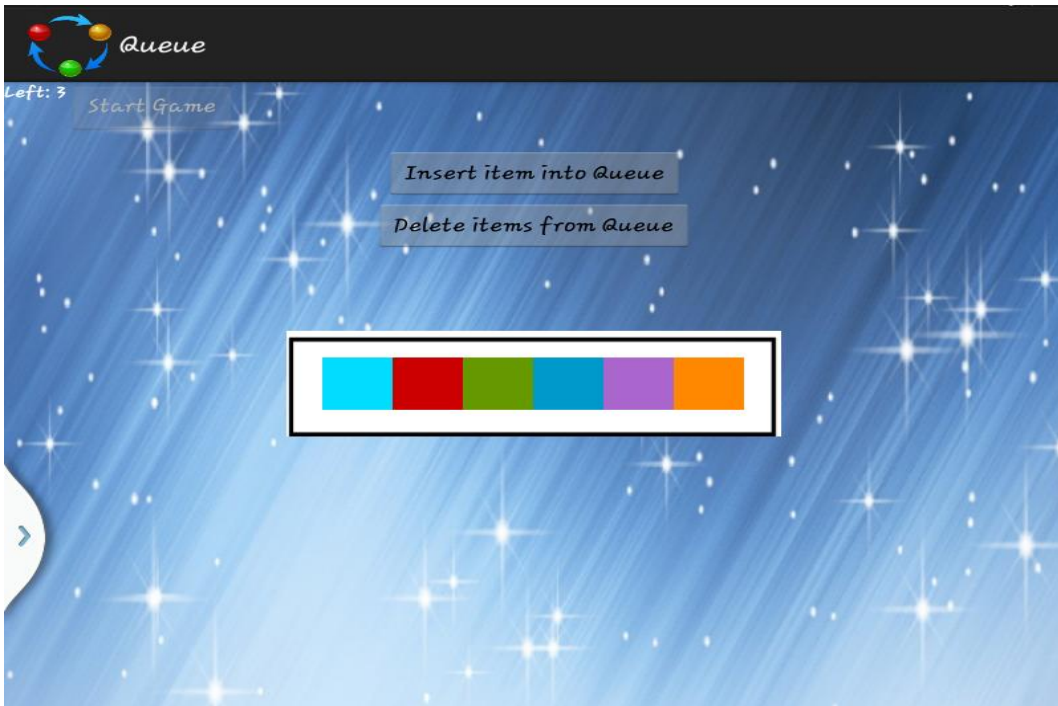
Figure 3.25 Queue after Insertion
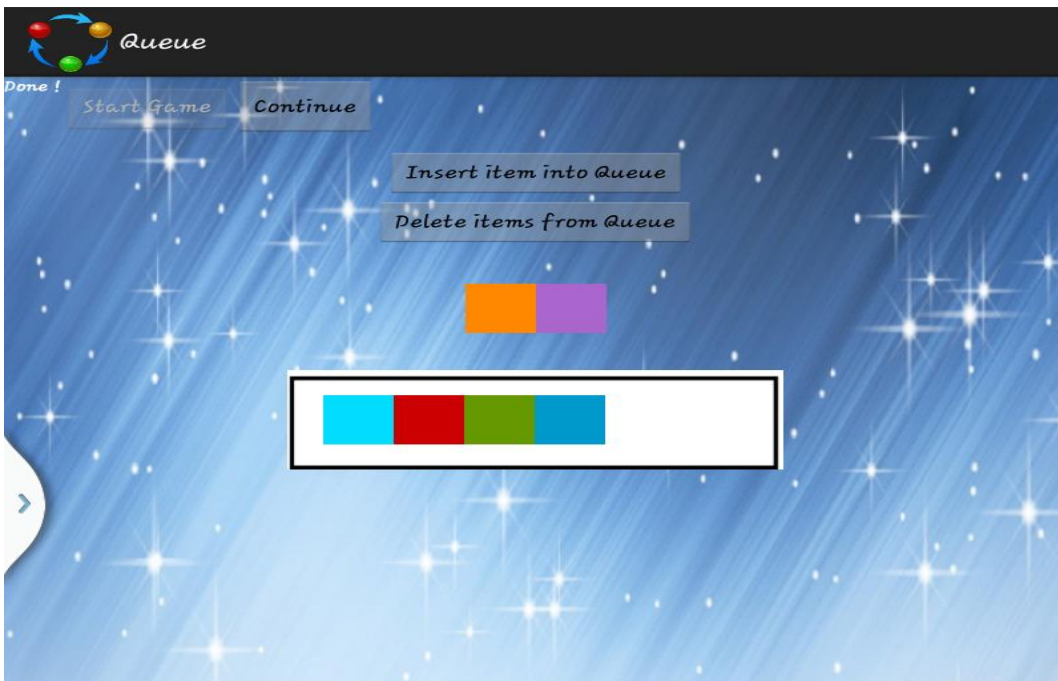
Figure 3.26 Deletion of items from queue

After completing the level 3(Queue), level 4(Binary Search Tree) will be enable. The screen grab of home page after completing level 3(Queue) is given in figure 3.27. Here user can see that lock from the level 4(Binary Tree) is opened now.

Figure 3.27 Home screen after completing level 3(Queue)

After this, user will click on level 4 to perform the task. On pressing level 4 button, new screen will be opened. The next screen opened will be the dialog box which will give instructions about the working of Binary Search Tree. The screen cast of this dialog box is illustrated in figure 3.28. After reading the instructions press on "continue" button to perform the main activity of Binary Search Tree. The screen cast of the main page of a Binary Search Tree activity is given in figure 3.29. On the main page of Binary Search tree user can see that there is a tree in which user has to insert the values which are shown on the screen. On clicking "Start Button" user will drag and drop these values in the correct position in a tree. User has to complete this task in 25 seconds.

Figure 3.28 Dialog Box for instructions of Binary Search Tree
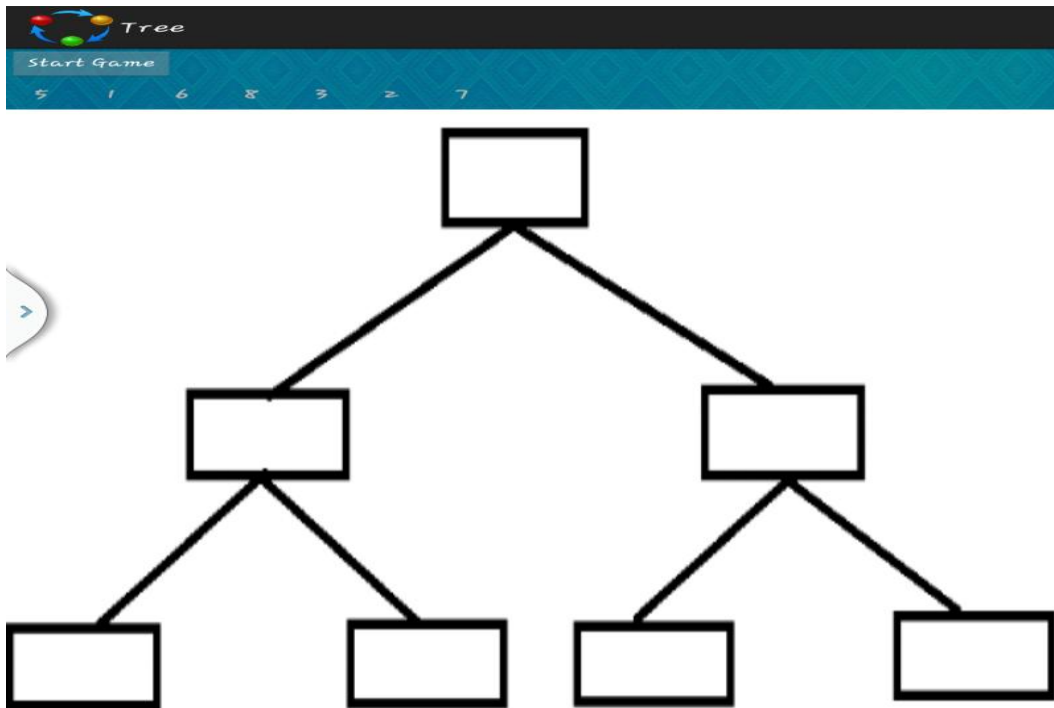
Figure 3.29 Binary Search Tree before insertion

If a user does not complete the task in required time, then dialog will appear on screen showing "sorry!" with sad emotion and if a user completes the task in required time, then there will be a dialog box showing "Awesome!" with smiley, The screen shots for these dialog boxes are already mentioned in figure 3.11 and figure 3.12. The screen shot of Binary Search Tree after the insertion of values is illustrated in figure 3.30. In the figure, it can be seen that the values which are greater than root node will be inserted on right subtree and the values lesser than the root node will be inserted on left subtree.
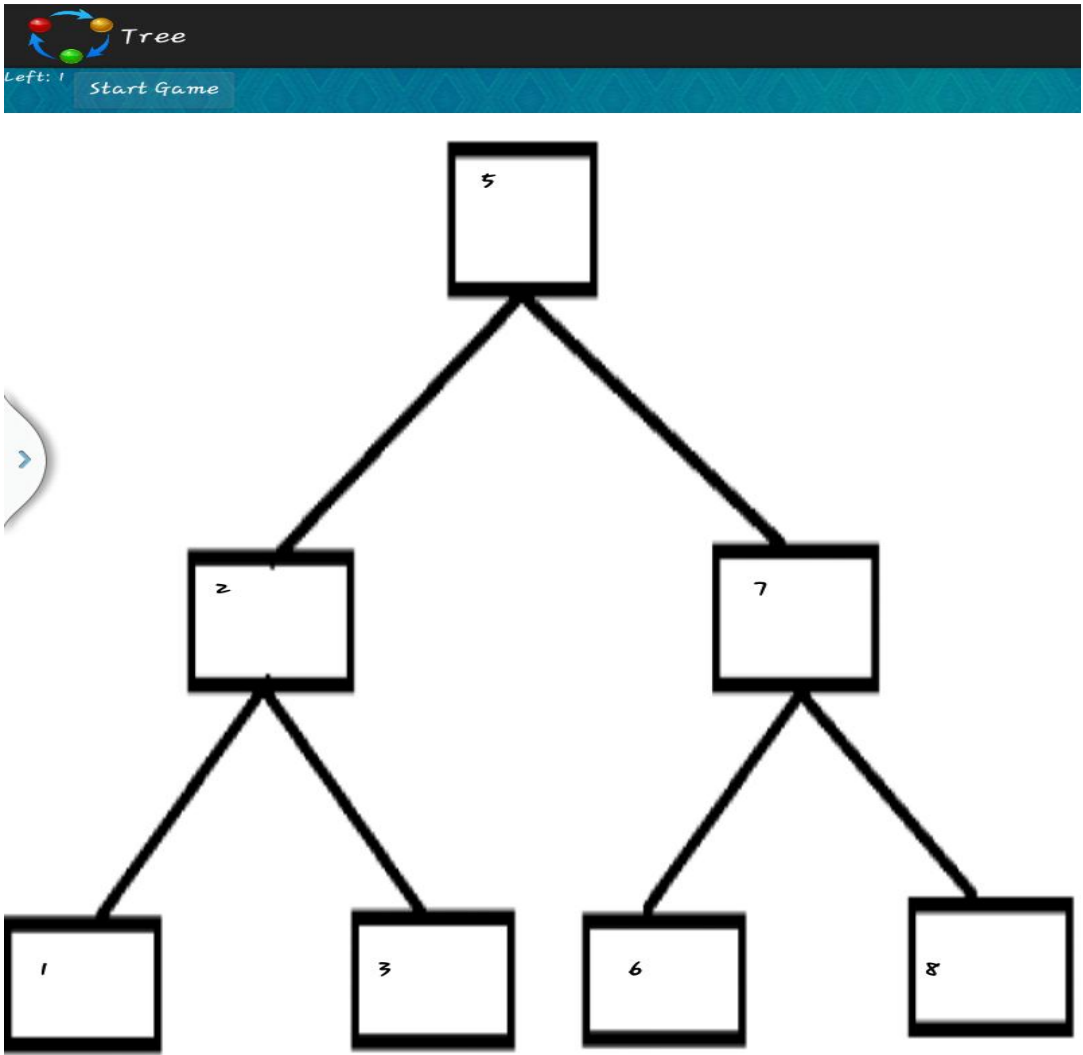
Figure 3.30 Binary Search Tree after insertion

After the completion of the task of level 4 (Binary Search Tree) there will be a dialog box on the screen giving "Congratulations" on completing all the levels. The screen cast of this dialog box is shown in figure 3.31.
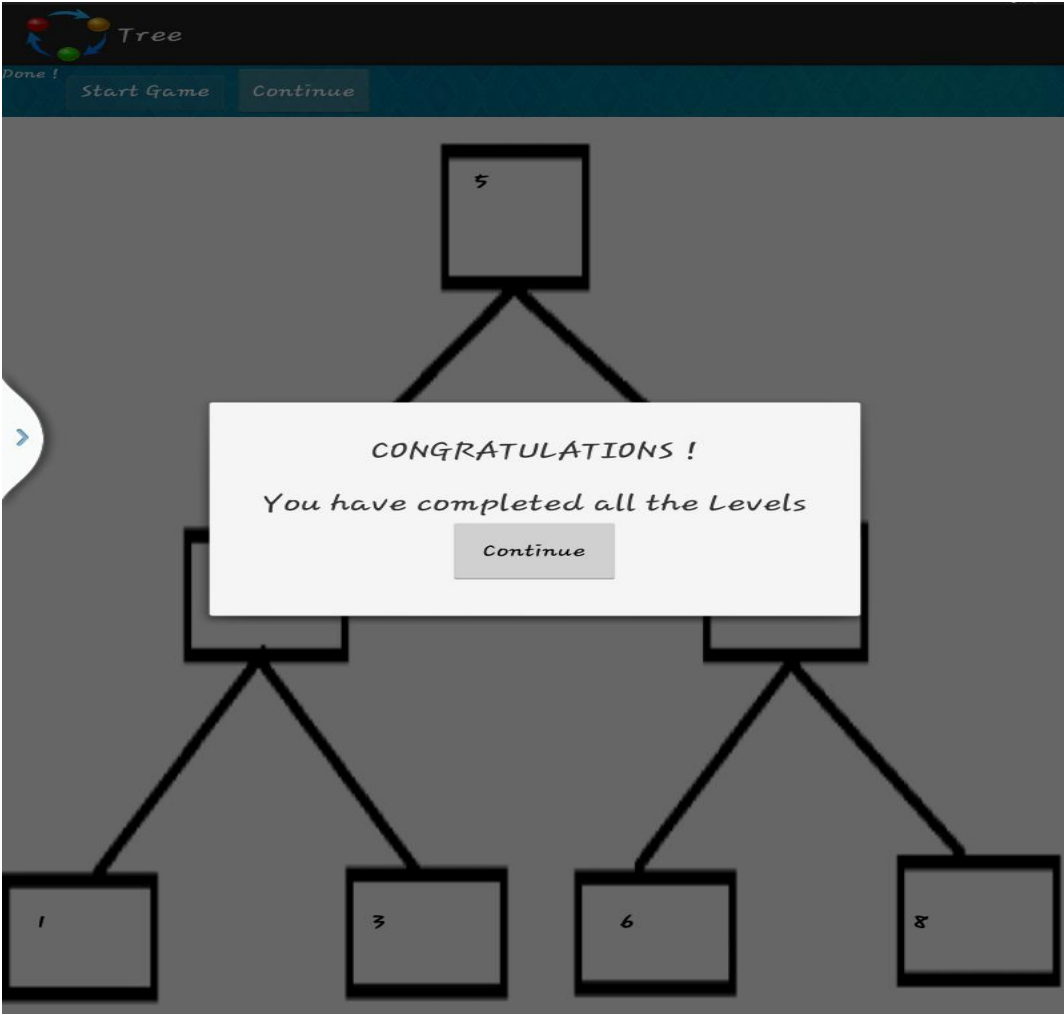
Figure 3.31 Dialog Box of completing all levels

After completing the level 4(Binary Search Tree), user will come to an end of the application Play and Learn DS. Thus this section provides the screen grabs of the implementation of different activities in application based on the workflow diagram discussed in previous section of this Chapter.

3.4 Conclusion

This chapter describes the design and implementation of the Play and Learn DS application. The application is very user-friendly and, it is very easy to use. This application is very helpful for the new students of computers. They can be able to easily understand the basic concepts of Data structure in a gamified and an interactive way. The screen casts with their description is discussed in section 3.3 of this chapter.

Chapter 4

Results and Performance Evaluation

This chapter describes the results of the Play and Learn DS application. In next sections, it can be seen that whether it is successful in achieving its objectives or not. Part 4.2 provides the performance evaluation of the application. The results of the application are presented through the graphs and tables in section 4.1. Results have been created by survey. In a survey, we include 100 new students of computers. The results of the survey are presented below. The main characteristics of the application have been shown in table 4.1 below.

4.1 Results of the Play and Learn DS application

Factors	Characteristics
Output	Improve learning process of DS
Space required	10.3 mb
Compatible versions	From 2.33 gingerbread to Kitkat
Interface	Graphical user Interface

Table 4.1 Characteristics of the application

In the above table, characteristics of the application are described. It shows that it improves the learning process of Data Structure. Only 10 Mb space is required to run this application. And the interface of the application is Graphical User Interface.

Following graphical representations shows the results of the survey. For finding the results survey has been done on 100 new students of

57

computers. Two quiz was administrated to determine the knowledge of students about the subject data structure. One quiz was administrated before playing the game, and one quiz was held after playing the game. There were 20 multiple-choice questions related to Array, Stack, Queue and Binary Tree. The students were told to answer the questions in the quiz. The scores gained by the students are shown in the table below.

Scores	Number of students
0-5	23
6-10	50
11-16	25
16-20	2

Table 4.2 Scores before playing game

The graphical representation of the above table is illustrated in graph below.
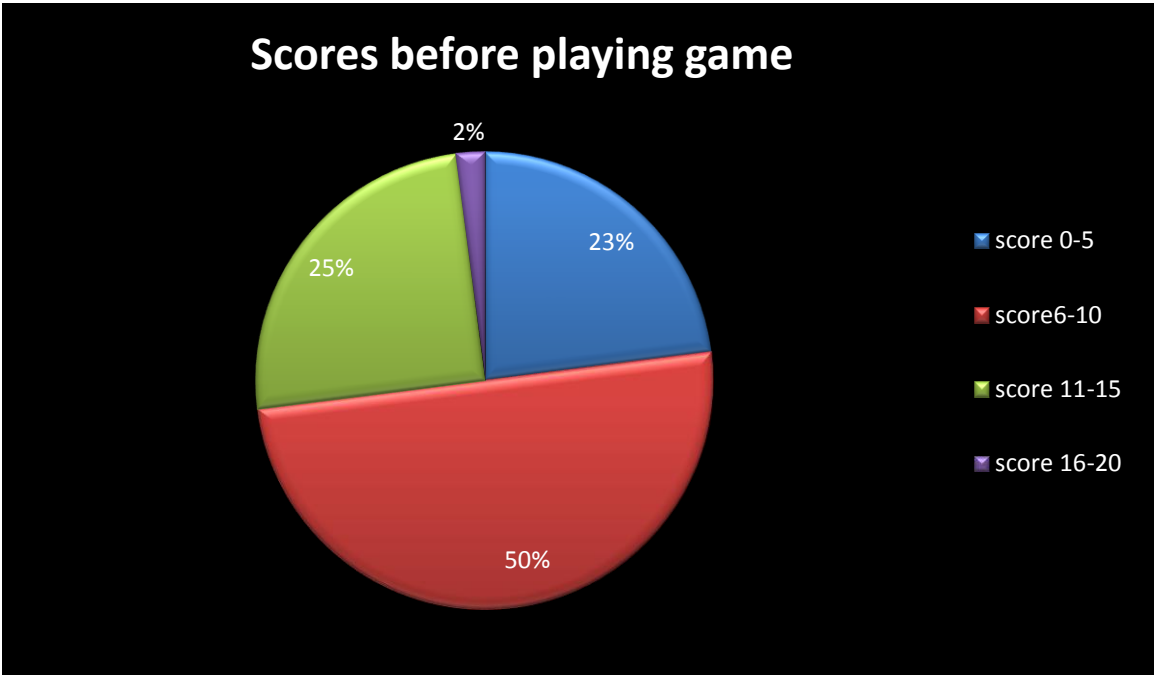
Graph 4.1 Scores of students before playing game

From the above graph, it can be seen that 23 percent students got 0 to 5 marks. They have little knowledge of the data structure. 50 percent student gained 6 to 10 marks; 25 percent students got 11 to 15 marks, and only 2 percent students got 20 marks.

After this quiz, game was given to the students to play. After playing this game, same quiz was administrated again to those students. The scores gained by the students after playing game are shown in the table below.

Scores	Number of students
0-5	15
6-10	40
11-15	31
16-20	14

Table 4.3 Scores after playing game

The graphical representation of the above table is given in graph below.
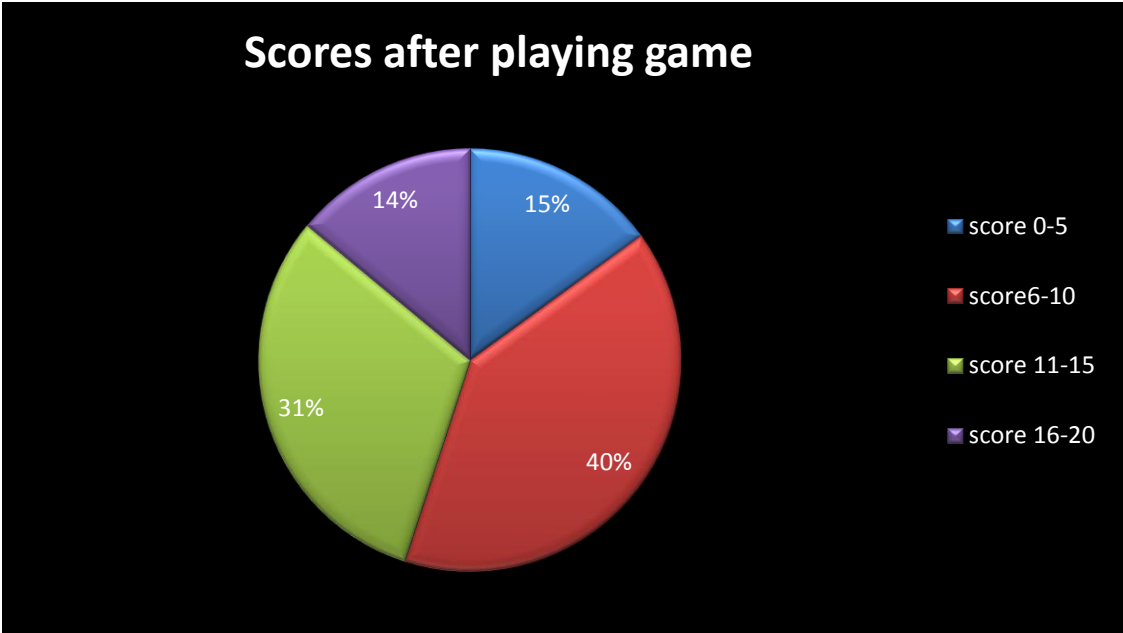

Graph 4.2 Scores of students after game

From the above graph, it is clear that knowledge of students has been increased after playing the game. 31 percent students got 11 to 15 marks. And fourteen percent students got between 16 and 20 marks. Thus from the above outcome, it has been proved that the game is successful in its motive. Clearly gamified application can able to improve the learning process of DS. There is a graph below which shows the comparison of knowledge of DS among students before and after playing game.

Performance of students before and after playing game

	score 0-5	score 6-10	score 11-15	score 16-20
Before	23	50	25	2
After	15	40	31	14
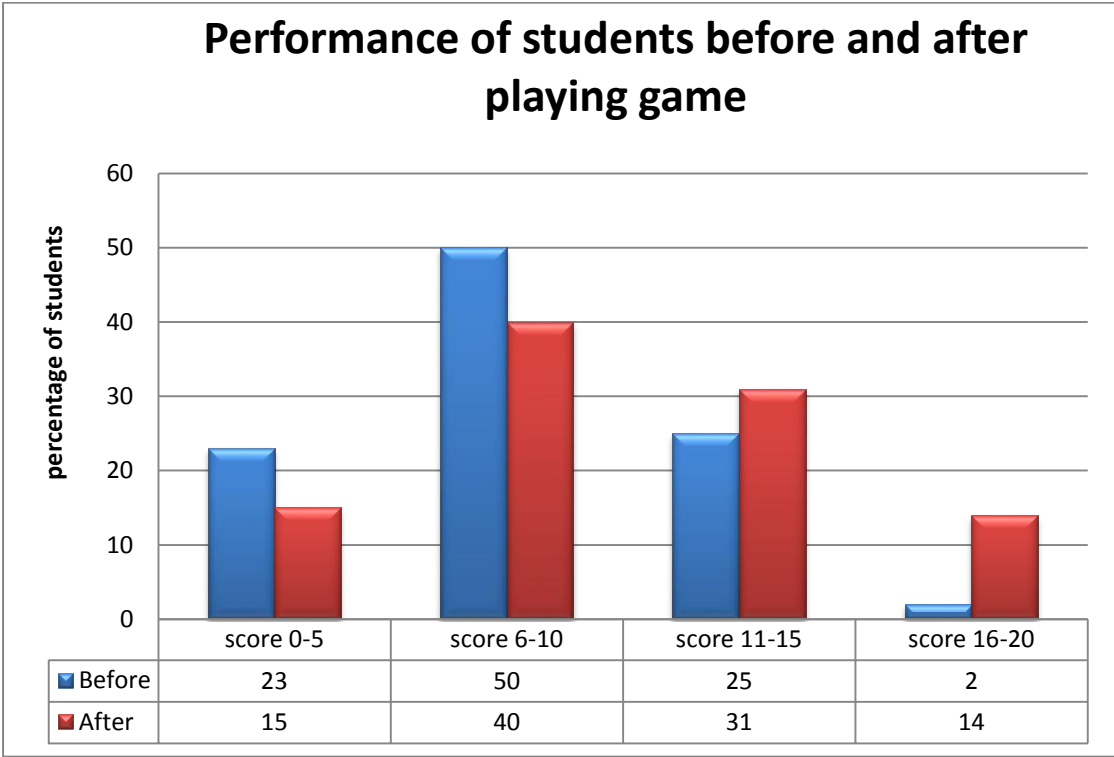
Graph 4.3 Performance of students before and after playing game

4.2 Performance analysis of "Play and learn DS" Application

The time and space complexity would be calculated in this section to analyze the performance of application. The space complexity refers to the required space for completion of the program. The distinct requirement for memory space of different modules has been given in table below.

Table 4.4 space requirement of different modules in application

Modules	Space required
Array	3.98 mb
Stack	2.02 mb
Queue	2.10 mb
Binary search tree	1.93 mb

Time complexity is another factor that is required to find the performance of application. Firstly, we find the loading time of each module of application. Loading time refers to the time taken by each part of application to load. Table 4.5 shows the loading time of each module.

Table 4.5 Loading time of each module

Modules	Loading time
Array	2 sec
Stack	3 sec
Queue	3 sec
Binary Tree	4 sec

From the above table, we can see that array takes more time to load among all modules, stack and queue has same loading time and binary tree has less loading time among all the modules.

After finding the loading time, we analyze the task completion time of each module. The time taken by the user to complete each activity is the task completion time. Time taken by users to complete the task is shown in following table.

Table 4.6 Task completion time of user

Modules	Task Completion Time
Array	22.73 Sec
Stack	6.50 Sec
Queue	10.76 Sec
Binary Tree	20.11 Sec

The graphical representation of above table of task completion time is shown below.
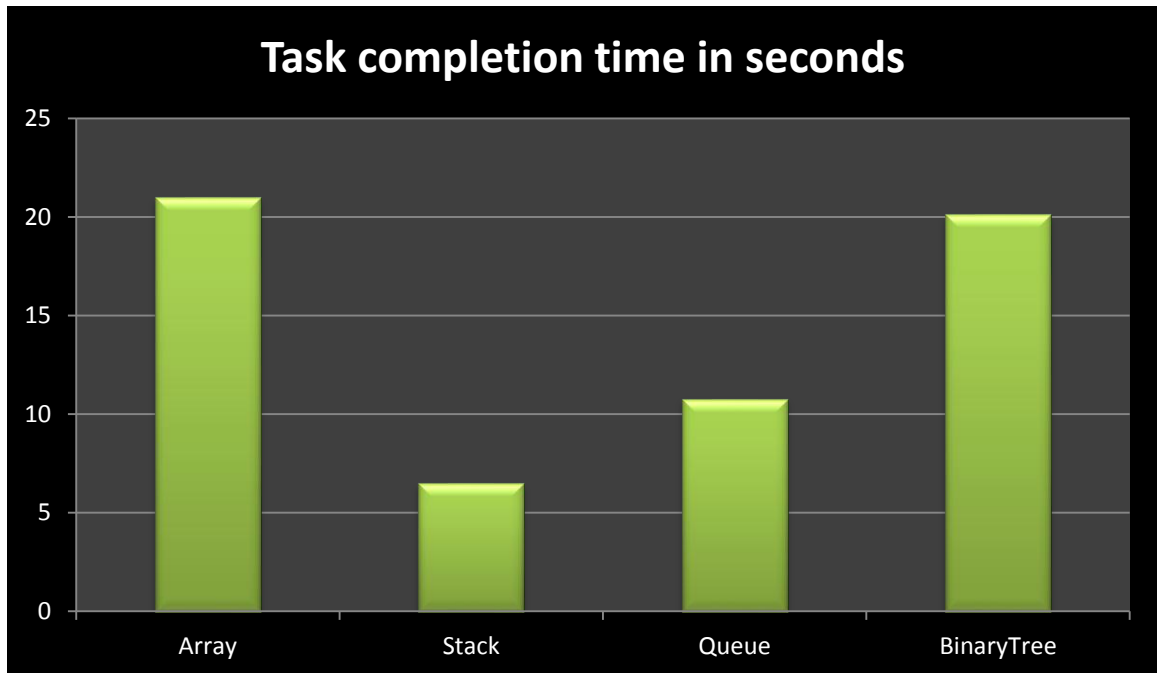
Graph 4.3 Task Completion time of user

Graph 4.6 shows that users take more time to complete the task of Array in required time. Stack take less time among all the activities. The queue is on third number to complete the task and binary tree takes time approximately same as the array.

4.3 Performance comparison of Play and Learn DS Application

Table 4.7 Performance comparison of Play and Learn DS application

Applications / Factors	TRAKLA-2	VELLA'S Game for sorting algorithm	Play and Learn DS application
Competitive learning	Yes	Yes	Yes
Online learning environment	Yes	No	No
Sorting algorithms	Yes	Yes	Yes
Sorting algorithm with time and space complexity	No	No	Yes
Comparison of algorithms	No	No	Yes
Array activity	No	No	Yes
Stack activity	No	No	No
Queue activity	No	No	Yes
Binary tree activity	No	No	yes

From the above table of performance comparison of the application, it is clear that this application is better than other applications to enhance the learning process of DS. It provides all the sorting algorithms along with their time and space complexity. And it also provides the comparison of different algorithms to understand that which algorithm is better for sorting items. Along with this, it also includes the activities of basic concepts, which are more important to clear.

4.3 Conclusion

This chapter describes the results of the application in the form of graphs. The above results of the application have proven that this application is beneficial for improving the learning process of subject data structure. This gamified application improves the understanding of the subject. After the results of the application performance, analysis has been done based on each module of application. Thus from the results, it is clear that the gamified application is successful in its objective.

Chapter 5

Conclusion

Results of the game prove that this application is successful in achieving its objectives. The "Play and learn DS" application is useful in increasing learning process of DS. The knowledge of students has increased after playing the game. After the results, performance comparison of this game has been done with other applications. From the performance comparison, it is clear that this game is more helpful for understanding the basic concepts of data structure. Moreover, this application can provide the sense of self-learning.

In future this application can be extended by including other concepts of the Data Structure. Also we can use this technique of gamification for implementing other subjects, which can be helpful in learning process.

References

[1] Kai Erenli, "The Impact of Gamification", 15th international conference on

Interactive Collaborative learning (2012), page(s) 1-8.

[2] Sanat Kumar Bista and Surya Nepal, "Using Gamification in an Online Community",

2012, 8t[th] international Conference on Collaborative Computing., page(s)- 611 – 618.

[3] Irfan E. Kanat, Sathananda Siloju, T.S Raghu, Ajay s. Vinze, "Gamification of

Emergency Response Training", 2012, international conference on intelligence

and security informatics, page(s):134-136.

[4] Edna F. Reid, "Crowdsourcing and Gamification techniques in *Inspire* (AQAP

Online Magazine)", 2012 international conference on intelligence and security

Informatics, page(s):215-220.

[5] Chantzi Athanasia Eleftheria and Plessa Chariklea, "An Innovative Augmented

Reality Educational Platform Using Gamification to Enhance Lifelong Learning

And Cultural Education", 2013 fourth international conference on IISA.page(s):1-5.

[6] Rahul Saha, Riyanka Manna, Dr.G.Geetha, "CAPTCHINO-A Gamification

Of Image Based CAPTCHAs to Evaluate Usability Issues", 2012 IEEE, International

Conference on computing sciences. Page(s):95-99.

[7] Marget hall*, Steven o.kimburgh*, Christian Haas, Simon caton, "Towards the

Gamification of Well Being Measures", 2012 IEEE third international conference on Cloud and green computing. Page: 1-8.

[8] Foong Li law, Zarinah Mohd Kasiram, Chun Kiat Gan, "Gamification Towards Sustainable Mobile Application", 2011 5th Malaysian conference in software Engineering. Page(s): 349-353.

[9] Daniel J Dubois, "Toward Adopting Self Organizing Models", 2012 international Workshop on games and software engineering, page(s):9-15.

[10] Aida Azadegan and Johann c.k.h Riedal, "Serious Games Integration In companies: A Research and Application Framework", 2012 12th International   Conference on advanced Learning Technologies. Page(s):485-487.

[11] Christien Knoeze and Martin S Olivier, "Gamifying Authentication", 2012 IEEE Conference on information security for South Africa. Page(s):1-8.

[12] David N.Crowley, John G.Breslin, Karen Young, "Gamification of Citizen Sensing Through Mobile Social Reporting", 2012, International Games Innovation Conference. Page(s):1-5.

[13] Philipp Herzig and Michael Ameling, "A Generic Platform for Enterprise Gamification", 2012 Joint working Conference on Software Architecture and 6th European Conference on Software Architecture. Page(s):219-223.

[14] Joel And, "Gamification – a real world example", 2013 international conference on Collaboration technologies and systems. page(s):313-315.

[15] Basanth Kumar Neeli, "A Method to Engage Employees using Gamification in

BPO Industry", 2012 third international conference on services in emerging

Markets. Page: 142-146.

[16] Krishna Depura and Mohit Garg, "Application of Online Gamification

To New Hire Onboarding", 2012 third international conference on services in

Emerging markets. Page: 153-156.

[17] Haksu Lee and Young Yim Doh, "a study on the relationship between educational

Achievement and emotional engagement in a gameful interface for video lecture

Systems" 2012 International symposium on ubiquitous virtual reality. Page(s): 34-

37.

[18] Vaninha Vieira*, Adriano Fialho*, Victor Martinez*, Jailson Brito*, Lincoln Brito*

Adolfo Duran, "An Exploratory study on the use of collaborative riding based on

Gamification as a support to Public Transportation" 2012 Brazilian symposium on

Collaborative systems. Page(s): 84-92.

[19] Kevin Bierre, "Implementing a Game Design course as a Multiplayer Game" 2012

IEEE International Games Innovation Conference (IGIC). Page(s): 1-4.

[20] Ilana de Almieda Souza- concilio, Beatriz de Almieda Pacheco, "How to make

Learning management Systems more exciting and entertaining: Games, Interaction

And Experience Design" 2013 IEEE conference on e-learning, e-management and

e-services. Page(s): 18-23.

[21] Yotu Fujikawa and Manki Min, "A new environment for Algorithm Research using

Gamification" 2013 IEEE conference on Electro Information Technology (EIT).

Page(s): 1-6.

[22] Aldo Gordillo, Daniel Gallego, Enrique Barra, Juan Quemada, "The City as a

Learning Gamified Platform" 2013 IEEE. Page(s): 372-378.

[23] Edward Gehringer and Barry Peddycord, " Grading by Experience Points: An

Example from Computer Ethics" 2013 IEEE. Page(s): 1545-1550.

[24] Thomas D. Latoza, W.Ben Towne, Andre Vander Hoek, James D. Herbsleb,

"Crowd Development" 2013 IEEE. Page(s): 85-88.

[25] Ross Smith, "The Future of work is Play: Global Shifts suggests rise in

Productivity Games" 2011 International Games Innovation Conference (IGIC).

Page(s): 40-43.

[26] Laurent Maccozet, Camille Tardy, Wanda Opprecht, Michel Leonard, "

Gamification based assessment of Group Work" 2013 International Conference

On Interactive Collaborative Learning (ICL). Page(s): 171-179.

[27] Kutti Julius, "Designing Gamification" May 2013.

[28] Werbachk and Hunter D, "For the Win: How game thinking can revolutionize your

Business" 2012 Wharton Digital press.

[29] Per Hagglund, "Taking Gamification to the next level" 2013.

[30] Yongwen Xu, "Literature Review on Web Application and Analytics" 2012.

[31] Jose Berengueres, Fatma Alsuwairi, Nazar Zaki, Tony Ng, "Gamification of a

Recycle Bin with Emotions" 2013 IEEE. Page(s): 83-84.

[32] Lase Hakulinen, Tapio Auvinen, Ari Korhonen, "Empirical study on the effect of

Achievement badges in TRAKLA 2 Online Learning Environment" 2013 IEEE.

Page(s): 47-54.

[33] Hideki Tabata and Hiroshi Hashimoto, "WBL for Technical skill of

MONODZUKURI" 2011 SICE conference. Page(s): 2514-2517.

[34] Carlos Delgado Kloos, Abelardo Pardo*, Pedro J. Munoz-Merino, Israel Guttierrez,

Derick Leony, "Learning Analytics @ UC3M" 2013 IEEE Global Engineering

education Conference (EDUCON). Page(s): 1232-1238.

[35] Danae Vara, Enric Macias, Sergio Gracia, Alba Torrents, Simon Lee, "MEECO:

Gamifying Ecology through a social networking platform" 2011 IEEE International

conference on DOI. Page(s): 1-6.

[36] Christoph Thomas and Kay Berling, "Redesign of a Gamified Software Engineering

Course" 2013 International Conference on Interactive Collaborative Learning (ICL).

Page(s): 778-786.

[37] Kaiyang Zhang, Shihao Dong, Guoliang Zhu, Danielle Corporan, Tim Mcmullan,

Salvadar Barrera, "Pico CTF 2013- Toaster Wars" 2013 International Games

Innovation Conference (IGIC). Page(s): 293-299.

[38] Razwan Rughinis, "Gamification for Productive Interaction" 2013 8th Iberian

conference on information System and Technologies (CISTI). Page(s): 1-5.

[39] Konstantinos Giannakis, Konstantinos Chorianopouloc, Letizia Jaccheri," user

requirements for gamifying sports software" 2013 IEEE. Page(s): 22-26.

[40] Udeni Jayasinghe and Anuja Dharamratne, "Game Based Learning VS Gamification

from the higher education students perspective" 2013 IEEE International

Conference on Teaching, Assessment, and Learning for Engineering (TALE).

Page(s): 683-688.

[41] Dominguez, Saenz-de-Navarrete, De-Marcos, Fernandez-S, "Gamifying Learning

Experiences: Practical implications and Outcomes" IEEE. Page(s): 380-392.

[42] Hideki Tabata and Hiroshi Hashimoto, "WBL for technical skill of

MONODZUKURI" SICE Annual Conference, 2011. Page(s): 2514-2517.

[43] foursquare. foursquare. http://foursquare.com/.