Gamification to Enhance Learning Using Gagne's Learning Model

R Sreelakshmi
Amrita E-Learning Research Lab
Amrita Viswa Vidyapeetham
Amritapuri, India
sreelakshmir19@gmail.com

ML McLain
AMMACHI Labs
Amrita Viswa Vidyapeetham
Amritapuri, India
ammassarala@gmail.com

Abhishek Rajeshwaran
Amrita E-Learning Research Lab
AmritaViswa Vidyapeetham
Amritapuri, India
rabhishek@am.amrita.edu

Bhavani Rao
AMMACHI Labs
Amrita ViswaVidyapeetham
Amritapuri, India
bhavanee@amrita.edu

R Jayakrishnan
Amrita E-Learning Research Lab
Amrita ViswaVidyapeetham
Amritapuri, India
jayakrishnanr88@gmail.com

Kamal Bijlani
Amrita E-Learning Research Lab
Amrita ViswaVidyapeetham
Amritapuri, India
kamal@amrita.edu

Abstract— Technology enhanced Learning has brought drastic changes in the field of education in the modern world. In this study we explore a novel way to improve how high school students learn by building a serious game that uses a pedagogical model developed by Robert Gagne. By integrating serious game with principles of Gagne's learning model can provide engaging and meaningful instructions to students. The game developed in this study is a waste sorting game that can easily and succinctly demonstrate the principles of this learning model. All the tasks in the game that the player has to accomplish correspond to Gagne's "Nine Events of Learning". A quiz is incorporated in order to get data on the progress made by the player in understanding the concept and as well as to assess them. Additionally, an experimental study was conducted which demonstrates that game based learning using Gagne's event is more effective than a traditional classroom setup.

Keywords— Game based learning, Sorting and recycling of waste, Gagne's learning model, Technology enhanced learning.

I. INTRODUCTION

There are various teaching and learning methods in day-to-day life such as online learning, web-based learning and so on [1]. However some technologies such as,web-based learning is subjected to poor instructional design and multimedia content [2]. In order to overcome these issues, we are building a serious game on waste management, which combines sufficient multimedia content and simulations. This game also includes the pedagogical aspects of Gagne's model to promote learning of high school students in which the student learns about generation, segregation and processing of waste from various buildings. This knowledge helps the learner to keep the environment clean and healthy.

With increasing population, the quantum of municipal waste has increased many folds and there is an urgent need to implement appropriate waste management methods. This game provides necessary information on waste management and its importance. This game has three sections: an introduction, objective declaration and recall of prior knowledge. A pre-test is conducted before start of the game to test the prior knowledge.

There are three levels in the game. The performance of each player in the game is determined from the score of the quiz, which is conducted at end of each level to comprehend knowledge.

We have conducted a survey on various learning models: Bloom's taxonomy, Keller's model, and ADDIE model, to select appropriate model for this instructional design. Instructional Design is a standard development of instructional representation using learning theory to ensure the quality of instruction. In the gamification of web-based learning, ADDIE model, Keller's model, Bloom's taxonomy can be applied, depending on the game elements required in the game. In this paper, we employ Gagne's nine events, compared to other models, because it provides learning outcomes which are testable and accessible. This game invokes learning outcomes in accordance with the nine events of Gagne's learning model: gaining attention, informing learner of the objective, stimulating recall of prior knowledge, presenting information, providing guidance, eliciting performance, providing feedback, assessing performance, enhancing retention and transfer. This approach can improve the thinking ability, internal motivation and desire to learn through a game.

II. RELATED WORKS

José Luis Soler, Pau Mendoza and Sheila Pons-Vazquez [3], have conducted a study to evaluate the performance of students through game based learning. The main objective is to use a video game in classroom and noting the academic performance, intrinsic motivation of students. A study is conducted comparing the academic performance (test conducted) and motivation of two groups of students. Group A is provided class in traditional way while Group B has used video games for studying the topic. They have evaluated that group A has improved their knowledge lower than group B from the test on content related questions. This study proves that game based learning improved the performance & motivation of students.

Heide Lukosch and Theo van Ruijven [4] describe the outcomes of the project on development of serious game, a

virtual training environment for close protection. The main objective of game is to train police officers and other security guards to improve the situational awareness i.e. recognition of attacker's behaviour, team communication and co-ordination. They are training the people in a safe environment through a game rather than training them in a real world. It helps them to take right decisions. Therefore, these skills help the police officers and guards to improve and manage the situation during the attack.

The design of computer games has become more complex and realistic with increasing possibilities of virtual visualisation. Knowledge transfer from virtual to real world occurs through serious games. So the user can better understand the concept of real world problem through virtual visualisation. Simulations such as incident commander prepare people to respond to the natural disasters or crisis situations. This paper adopts two types of game design for the project: Quest3D design and UDK game engine.

Stefan Greuter and Susanne Tepe [5] [6] describe a computer game developed as a part of classroom activity to motivate the students to learn about hazards on construction site using OH and S control. To overcome the injury in construction sites, Australian construction commissioner has insisted the workers at the construction site to strictly complete an occupational Health and safety construction Induction process. One of the sections of the training deals with the identification and the management of hazards to control and prevent workers from injury. The key challenge in this game is to engage learners. This paper presents the design decisions and development of game to motivate users in learning about workplace hazards. It helps users to gain knowledge about the hazards and their management in the real world.

III.SOLUTION APPROACH

The serious game, Waste Management, handles Gagne's Learning Model to provide pedagogical aspect to the content. **Gagne's learning** model [7] aims at disseminating purposeful learning. Majority games are designed for training programs, which lack Gagne's learning model. However, in this game, we employ this model at various stages of the game. There are several instructional design models, but the entire criteria of each model cannot be defined in a single game.

We have conducted an experiment on the performance of students with respect to traditional and game based learning. In [8] they propose learning models like Blooms, Gagne's and constructivist model and they look at an approach to provide an efficient way for algorithm learning using the combination of three models. In this approach, they are not determining the learning outcome of learner.

In this paper, we apply a standard test to assess the performance of students. The learner outcome is determined from the pedagogical aspects of Gagne's model. We adopt the Gagne's model in our game to design a game play, achieve the learning outcomes and to arrange these outcomes in a specific game event. A test is conducted at the start and end of the game in accordance with this model to scrutinize whether they have understood the concept. The questions in the test are related

to the knowledge and eliciting performance levels of Gagne's events.

There are nine events of gagne's model that are addressed in the game that is as follows.

1. **First event of Gagne's model, Gain attention of students**-This event is designed in such a way that the students should be motivated to learn the underlying concept. In order to achieve this attention, an introductory video on the collection, sorting and treatment of various types of waste should be included.

2. **Second event, Inform students of objectives**-In this event, the objective of the game is specified before the game play. This instruction provides awareness on the player about various kinds of wastes and their management. This awareness is achieved in a step-by-step fashion while the player moves through the game. For example, at the beginning the player is given information about various types of waste he needs to sort with respect to their category: biodegradable and non-biodegradable. This sorted waste is sent for further treatment.

3. **Third event, Stimulate recall of prior learning**-This event helps students in associating his prior knowledge with the new knowledge. In the game play with respect to this event, the player will be introduced with different kinds of waste and provides situations, which recalls the prior knowledge about waste. The player is then directed to level 1 of the game: collection of waste from the city. A pre-test is conducted at this stage, to recall the prior knowledge of students from the knowledge levels of Gagne's model. The questions in the test will be of multiple choice or objective type.

4. **Fourth event, Present the content**-The game, at this stage, begins with a well-organized introduction about the content at each level. The relevant contents of the game are provided such as various categories of waste: recyclable waste and non-recyclable waste. As an example, if the player disposes plastic in a green colour coded bin, he will be provided contents in the form of instruction: "*Plastic is a recyclable item. You are putting it in a wrong bin*".

5. **Fifth event is, Provide learning guidance**-The player will be given proper guidance in the form of instruction support such as hints, prompts which can be detached after students understand the content as shown in fig.4. For example, the player will be asked to sort the waste and deposit it in proper bins. If the player clicks a banana peel and put in it a blue colour bin, he will be given a hint: "*Banana is a green waste. It is taken for composting only*".

6. **Sixth event, Provide feedback**-Feedbacks are provided at each stage for the right or wrong action. For example, if the player puts the green waste inside green bin, he will be given comment: "*good work*".

7. **Seventh event corresponds to, assess performance**-In order to rate the performance of the player, a post-test is conducted at end of the game. Questions for this test are structured using the learning outcome in the Gagne's model. The three main learning outcomes are verbal information, intellectual skills, and cognitive strategy, which are explained below. From this test, the understanding of the student about the concept is analyzed.

8. **Eighth event, eliciting performance**- This event shows the understanding of the player performance through the game play. As an example, in this game play, the player picks the papaya waste and disposes it in the green bin. He already stores in his memory that papaya is a food waste and it should be put in a green bin. The player co-relates his prior knowledge with the new idea he got by playing the game. It also estimates the success or failure of the player in the game.

9. **Lastly, Enhancing retention and transfer**-In this event, the player should be able to apply his knowledge to develop a new model or a situation with similar model. For example, in the game play, finally, the player is insisted to build a model with a city and to manage the waste in the designed city. He is provided with entire arrangements for this exercise such as various colour-coded bins and wastes.

At the end of the game, the learner will achieve certain learning outcomes based on Gagne's model. The player will be able acquire verbal and visual information and intellectual skill. Initially, the player will be introduced with various waste materials with a definition about the waste. It provides both verbal and visual information to the learner. The following questions are framed to test the verbal information:

1. State the definition of vermi composting.

It is the process of composting using various worms to convert organic waste into fertilizer.

2. State the definition of term incineration.

It is the process of burning the waste in absence of oxygen.

At the second stage, the player categorizes the waste and deposits it in proper bins. He distinguishes the type of waste and various treatment methods of waste, which improves the intellectual skill. Few sample questions that will be used to assess learning outcomes from the game have been included here. The following are questions framed for testing the intellectual skill.
1.Distinguish between biodegradable and non-biodegradable waste.

The materials that can be decomposed are biodegradable waste and the materials that cannot be decomposed like plastic, metal etc. are non-biodegradable waste.

2. Distinguish between aerobic and anaerobic composting.

Aerobic composting is done above ground composting and anaerobic composting takes place in underground pits or trenches.

The game is designed using unity 2D. The game engine supports languages such as C sharp, Java script and Boo. It also incorporates physics properties, animations and textures as properties. In this game animations are done in an attractive and user friendly way which makes the learner feel interested to play the game. The player moves through the shortest path by using a path finding algorithm [9]. It saves the time for picking the waste which are scattered around the city.

IV. GAME FLOW

From the pre-test and post-test conducted during each stage of the game, the effect of pedagogy on serious game can be analyzed. The tests estimate the level of understanding of each student, developed through a game. The evaluation, feedback and rewards are provided to students in accordance with the test to enhance learning with proper guidance. The students can easily understand a subject through game based learning rather than the traditional classrooms. The main advantage in a game is that the uses of pedagogy in a game can easily assess and evaluate the student's performance. It also helps students to gain knowledge.

Fig.1 illustrates the game flow. The game interface is designed to provide better understanding about the subject matter. The player must collect the maximum waste and segregate them according to biodegradable and non-biodegradable waste. Before starting the game, a pre-test will be conducted to check the prior knowledge of student based on gagne's model. There are three levels in the game. First level is collection, second level is sorting and third level is treatment of waste. At each level, there will be a quiz conducted to estimate the performance of a student in understanding the concept through each series of game. Instructions will be provided based on different kinds of waste as shown in Fig.3. The player in the next level will be given an introduction about the need for sorting and recycling of waste as shown in Fig.4. At the beginning of the game, waste appears and player has to come and collect within a time limit as shown in Fig.5. If the player fails to pick the waste within the time limit, the level will be over. The player has to replay the game until the entire waste is collected. The next level is segregation of waste based on bio-degradable and non-biodegradable. The wastes are then processed based on various categories. At the end, a post-test is conducted to assess the student's knowledge. They will be given feedback and motivation at the right time with respect to test results.
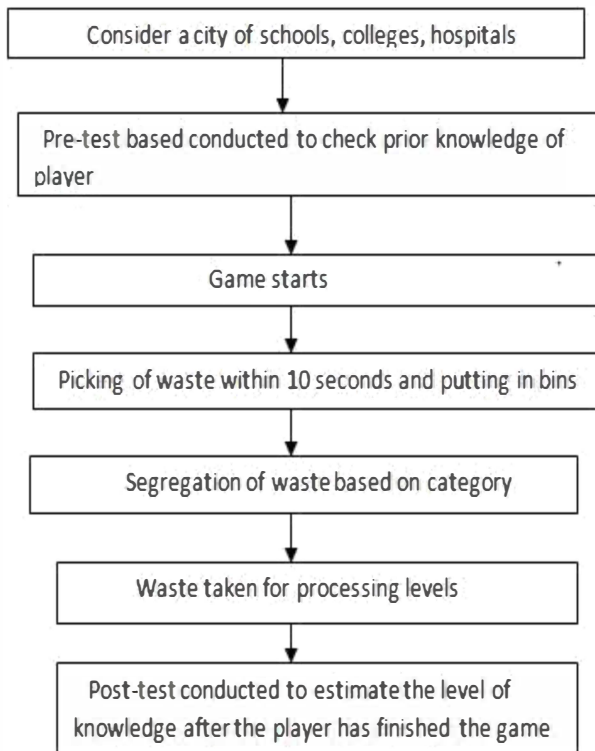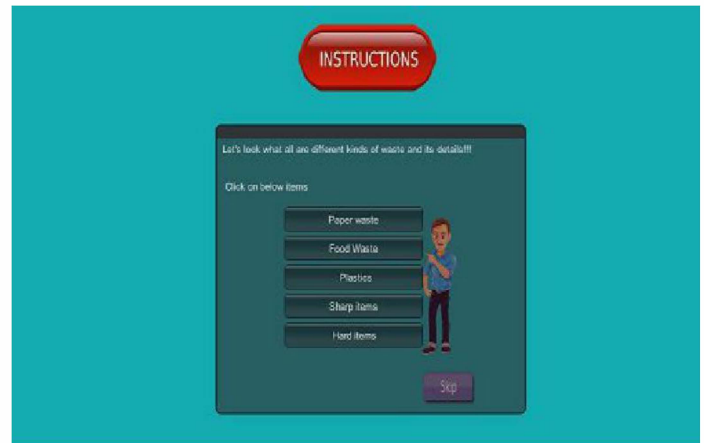
Fig.1 Flow diagram

Fig.3: The player given instructions regarding different grades of waste.

Fig.4 Player given an introduction on different kinds of waste and its categories.

Fig.2 Initial phase of game

Fig.5 Player has to collect the waste put in proper bins.

VI. RESULT AND ANALYSIS

A. Analysis on Student Distribution

An experimental study was conducted on school students in a rural area for exploring the effectiveness of Game-based learning over traditional learning. In order to support our experiment, 20 students were taken and divided into 2 groups of 10 each. The group1 students were categorized as Game-based learners, who were provided with a game on waste sorting and recycling. The traditional learners were categorized as group2 students in which a typical class was given on topic "*waste management*". A pile of waste was kept outside the school and separate colour coded bins were kept. Initially, group1 students were ordered to place the waste in proper bins. The performance of each student in the group1 was noted. We have found that out of 10 students, 7 students put the waste in right bins. In the next phase, group2 students were asked to dispose waste in proper bins. Among 10 students in group2, 5 students have placed the waste in appropriate bins. This result infers that about 50% of students could only succeed from traditional learning setup, while 70% of students from Game-based learning have succeeded through playing game as shown in fig.6.
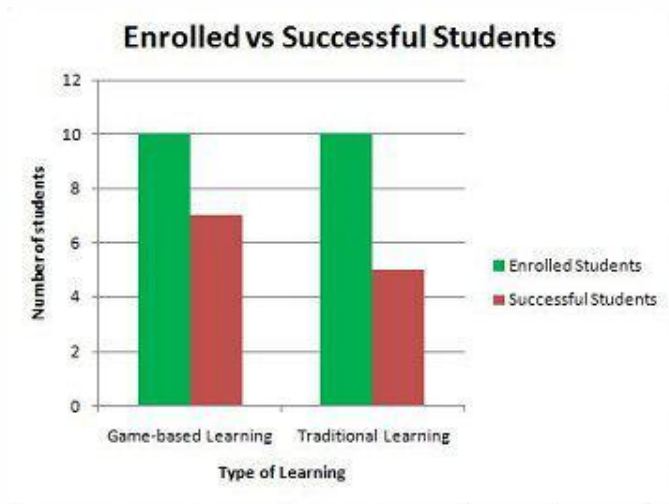

Fig.6 Performance of students

B. Analysis on Content Distribution

We have also conducted a study on same group of students to evaluate the content knowledge through a quiz, following both traditional and Game-based approach. The author was the instructor for the students. Author gave them traditional mode learners a class on topic "What are different kinds of waste and also how to sort and recycle them" There were two medium for study: one through game and other through learning with help of an instructor. Then they were given a quiz module with 10 questions.

The question contains both objective and subjective type questions. The students who played the game answered almost all answers correctly than the students who learnt with the help of guidance. From fig.7, it is clear that Game-based learners perceive more about sorting and recycling of waste through serious games.
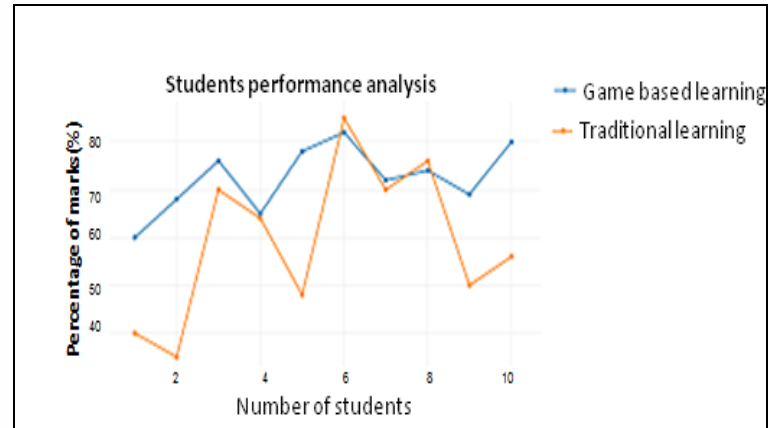

Fig.7 Marks obtained by Traditional and Game-based learners

The attention of students were less because they got distracted after a few minutes, but in a game based learning student attention to play the game and win the game is high. The students play the game through recall of prior knowledge. The objective of sorting and managing the waste can be easily achieved through game-based approach rather than just sitting and listening in a classroom. The direct involvement of student is possible in game which increases their motivation level and ability to do thing of their own. Feedback and assessment performance are almost equal in both approach because when a student answers a question assessment and feedback are given at the same time. In traditional setup the feedback provided at the right time by instructor itself and in a game feedback provided by computer. Finally an oral questionnaire section is conducted for both types of learners. Thus game-based learning enhances the standard of education and is one of the effective technologies used in learning.

From the above experimentation, a comparative study of Gagne's events on traditional learning and Game-Based learning was conducted as shown in TABLE I.

TABLE I COMPARISON ON GAGNE'S EVENTS WITH TRADITIONAL AND GAME-BASED LEARNING

Gagne's events	Traditional learning	Game-based learning
Attention of students	Comparatively less	High
Inform students about objective	Moderate	High
Recall of prior learning	Moderate	High
Present the content	Moderate	High
Learning guidance	Involvement of both instructor and student	Student Involvement only
Provide feedback	High	High
Assess performance	High	High
Enhancing retention and transfer	Less	High

VII. CONCLUSION

Gamification in technology enhanced learning improves the instructional design and multimedia content in designing learning materials. It is an effective teaching tool that makes learning interesting and engaging, leading to greater knowledge understanding and acquisition. Game based learning applications can draw us into virtual environments that appear familiar with the subject matter; thus enhancing new doors of innovation in technology enhanced learning. This study shows that using an instructional learning design method such as Gagne's learning model helps the students themselves to understand the concept and analyze how much they have learned by the score obtained during the quiz. The game looks at providing basic knowledge regarding waste management. It does not give exploratory information about the topic. This game includes three stages in municipal waste management: Collection, Sorting and Recycling. The other stages are discarded in the current design of the game as the increase in the complexity of the game may lead to more challenges thereby increasing the critical thinking of students. From the experimental study conducted it is clear that people learned more through game based approach than by traditional approach, showing that game based learning is more effective when compared to traditional classroom setup. Further research in this area can be done in the future to test this result with more complex games and more diversified populations.

Reference

[1] Online learning, http://en.wikipedia.org/wiki/E-learning.

[2] David A Cook, "Web-based Learning: Pros, Cons and Controversies", Clinical Medicine 7.1(2007):37-42

[3] José Luis Soler, Pau Mendoza, Sheila Pons-Vazquez," Impact of Video Games-Based Learning on Academic Performance and Motivation: a Case study".

[4] Lukosch, H. K., T. W. J. Van Ruijven, and Alexander Verbraeck. "The other city-designing a serious game for crisis training in close protection." *ISCRAM 2012: Proceedings of the 9th International Conference on Information Systems for Crisis Response and Management, Vancouver, Canada, 22-25 April 2012.* Simon Fraser University, 2012.

[5] Stefan Greuter, Susanne Tepe, J. Fiona Peterson, Frank Boukamp, Kimberley d'Amazing, Kalonica Quigley, Rhys van der Waerden, Thomas Harris, Tim Goschnick, and Ron Wakefield. 2012. Designing a game for occupational health and safety in the construction industry. In *Proceedings of The 8th Australasian Conference on Interactive Entertainment: Playing the System* (IE '12). ACM, New York, NY, USA,Article13,8pages.DOI=10.1145/2336727.2336740 http://doi.acm.org/10.1145/2336727.2336740.

[6] Stefan Greuter, Susanne Tepe," Engaging students in OH&S hazard identification through a game.", DiGRA: Defragging Game Studies. Digital Games Research Association, 2013.

[7]Gagne's learning model and its outcomes, http://education.purduecal.edu/Vockell/EdPsyBook/Edpsy3/edpsy3_out comes.htm.

[8] Sahar Shabanah, Dr. Jim X. Chen," Simplifying algorithm learning using serious games.", Proceedings of the 14th Western Canadian Conference on Computing Education. ACM, 2009.

[9] Path finding algorithm, http://www.dotnetperls.com/pathfinding