

Gamification of Web Based Learning Environment for Physics Problem Solving

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Abstract

In today's digital generation, gamification has become a popular tactic to encourage specific behaviors, and increase motivation and engagement. While having this idea successfully used mostly in business and commercial contexts, it's suggested that application of game mechanics can be used in web based education to ease the common pain points in education. Some common pain points in education such as focus, motivation, pride, physical-mental and emotional factors.

This paper addresses our work on gamifying the web based learning environment system for problem solving. The system's instructional design is based on Polya's problem solving model which consists of four stages: a) Understand the problem b) Devise a plan c) Execute the plan d) Review the solution. Both the social and self-elements of gamification are covered in gamification process of the system. Social elements include Leaderboards, Virtual Goods; whereas self-elements includes Points, Levels, Trophies and time restrictions. The gamification elements in the system are assume to help student to get more involved and engage with the system, eventually helping student to get most out of an e-learning system. This paper focuses on the design and application of gamification elements in the system.

Keywords: Gamification, education, engagement, visualization, e-learning, physics

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Introduction

Gamification refers to use of game mechanics in non-game environment to influence behavior and increase engagement [6]. Gamification has been incorporated with commercial success into platforms, i.e. badgeville, especially social ones, as a way to create narrow relationships between the platform and the users, and to drive viral behaviors on them to increase platform popularity. This success has made some researchers theorize that it also could be used in education as a tool to increase student engagement and to drive desirable learning behaviors on them [1] [6]. The main objective behind gamification in education is to apply some of these ideas in designing educative initiatives and their contents in an attempt to make them more motivating [6]. Gamification indirectly can increase the skill of students since it encourages them to perform an action. When students are motivated enough to act and practice their exercises it can increase their knowledge [3]. Lee and Hammer [1] believes that gamification, in coming years, will be a part of students' lives. It can play important part in making students to perform better in academic as well as real life if motivation and potential of gamification is directed towards education and learning. [1].

In this study, we focus on gamifying an adaptive learning environment for physics problem solving known as ALEPS. We have developed a web based learning system incorporating a set of gamification mechanics. Next section describe the ALEPS system (non-gamified) followed by Gamified system that include design functionalities and architecture. The last section presents conclusions and direction of our future work.

ALEPS System

ALEPS, an Adaptive Learning Environment for Problem Solving is based on Polya's problem solving strategies which include, understanding, planning, implementing and checking [13]. This system uses visualization to highlight and explicit the schemata.

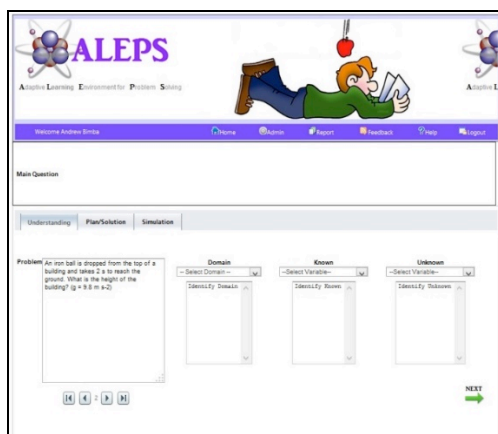


Figure 1: Understanding Stage.

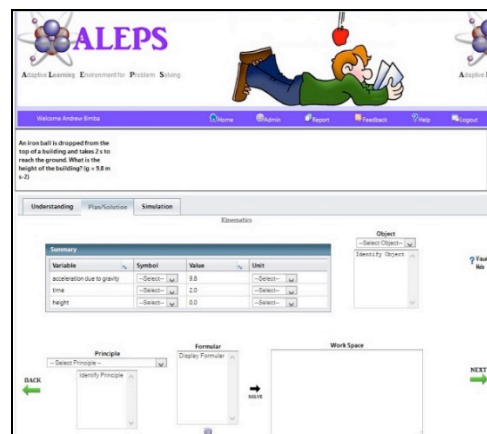


Figure 2: Planning Stage.

In the first stage which is understanding module (Figure 1), students have been provided a platform to acquire basic understanding of physics problem by pointing

out known/Unknown variables and domain in which problem falls in. The next stage is planning module (Figure 2) where student further proceed towards the solution by selecting principle involved and appropriate equation to solve the problem.



Figure 4: Visualization at final stage.

In planning stage, student have access to simulation environment specific to the problem where students can change the values of variables (i.e. mass, velocity, acceleration etc.) of an object to observe the effect of the change and to have some visual picture and understanding of real world scenario. After completing the planning stage, student can execute the plan to create visualization (Figure 4), where the objects are simulated as per student's selected principles and equations. Student will be notified of the result of the visualization. For checking and reviewing process, correct simulation of the specific problem is also provided in same stage as well.

Gamification of ALEPS

Lee and Hammer [1] [6], suggested that the gamification in education should concentrate on cognitive, emotional and social areas of user. Games are motivating because of focusing on these three areas.

Game mechanics are the mechanisms used to gamify an activity [12]. Most common game mechanics are shown in Table 1. As game mechanics are the rules and rewards of the game, intended to evoke determined emotions on the player, game dynamics are the desires and motivations leading to those emotions (Table 1).

Table 1. Common Game Elements

Game Mechanics/Elements	Game Dynamics/Behavior
Points	Reward
Levels	Status
Trophies, Badges	Achievement

Virtual goods	Self-expression
Leaderboards	Competition
Virtual gifts	Altruism

The proposed gamified ALEPS system includes some of the most usual game elements (Table 1) as follows.

- | | |
|---------------|-------------------|
| 1. Dashboard | 2. Coins |
| 3. Badges | 4. Levels |
| 5. Experience | 6. Progress meter |
| 7. Trophies | 8. Leaderboard |

System Design

As explained in last section, in ALEPS system the cycle starts from first stage of problem solving which is understanding the problem, followed by second stage of planning the solution and executing, finally the Visualization stage for reviewing and checking. However, student can go back to planning stage in case if of unsuccessful attempt. In order to implement the gamification mechanics, we upgraded the system by not only including the game mechanics but also few additional controls. Nevertheless, the main flow of problem solving in three stages remains same as shown in Figure 4, 5 & 6. The gamification mechanics adapted to ALEPS systems such as:

The dashboard: This control comes directly after the successful login of student, Showing the current progress and status of the achievements in terms of badges and trophies won. The leaderboard is students ranking which also shown in the dashboard. The link for full leaderboard is provided as a reference.

Problem Solving – How To?: This comes just before student starts to solve any problem and briefs explanation about the problem solving cycle to the student in descriptive as well as in pictorial form.

Progress Meter: During the process of problem solving using ALEPS, we have included the progress meter which updates its status after student successfully complete each stage. The intention to use this element is to make student aware of progress, helping him not to feel lost among multiple stages as well as keeping him motivated to finish the task of solving the Physics problem.

Score: ALEPS system originally calculates the score of every exercise done by student. The calculation of the score depends upon multiple factors such as: time taken to solve each question; number of wrong attempts in choosing known variable, unknown variable and domain of the problem. In this system, we have retained the score feature and its calculation formula.

Coins: Coins element is also implemented in this system. Some amount of coins is by default provided to the student upon the registration of the system. The student can

earn more coins by each successful action on choosing correct variable or principle or upon completion of each stage. Previously in ALEPS, the multiple level hints feature was given to students which started from basic hint to finally giving them correct choice. It was noticed in pilot study that students were using the hint feature in excessive manner without reading and understanding it properly. In this system the student uses coins to buy hint(s), which makes students to use hint feature cautiously, forcing them to read and understand. Student loses some coins too when he uses hit and trial method while selecting the correct variable.

Levels: In this system, the student will achieve higher level upon completion of successful attempts in solving each problem. The purpose of this element of gamification is to retain the student engaging with the system in long term.

Experience: Unlike the level element, the student gains experience value for each activity regardless level of activity or success of the activity. This element enabling students to remain motivated emotionally even if they make any wrong attempts which cost those coins or score.

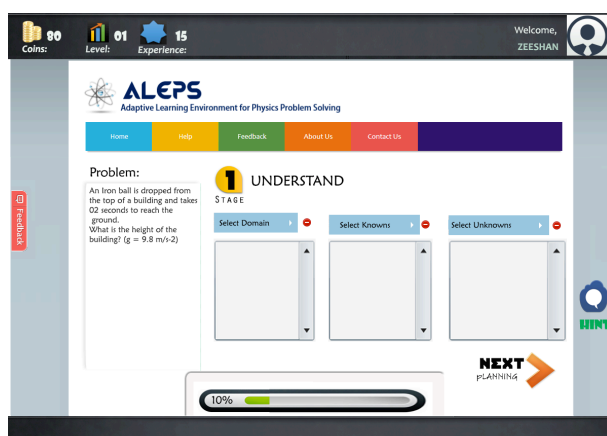


Figure 4. Understanding Stage

Badges and trophies: Students win badges and trophies as a reward for doing their exercises. There are varieties of badges and trophies have been introduced in this system to keep student motivated. Trophies and badges both highlight different achievements of the student. Three different levels of trophies such as Gold, Silver & Bronze are used for number of successful exercises. Whereas, different types of badges can be won by student on his different activities such as Beginner badge for completing first exercise, Regular Visitor badge by visiting online portal at least once a week.

Leaderboard: This element satisfies the social aspect by promoting competition among students. In this system the Leaderboard element shows the top students based on the results of various game elements used in this system such as: Score, Levels, Experience, Number of Badges and highest trophies.

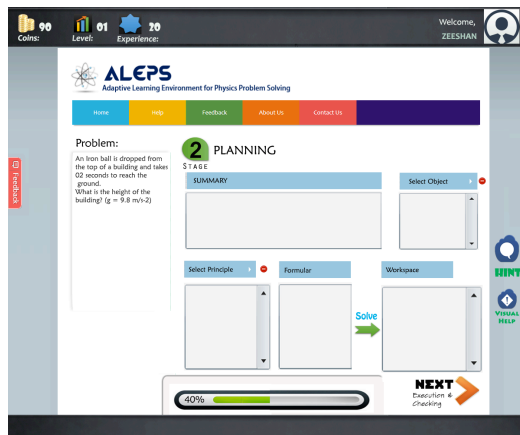


Figure 5. Planning Stage

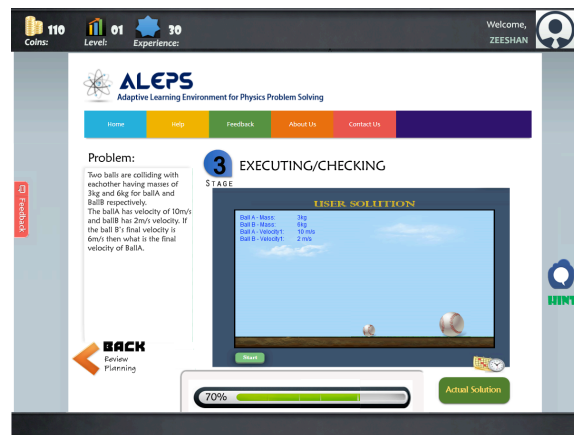


Figure 6. Executing/Checking Stage

System Features

The web application features are divided based on the roles of user.

1. Student:
 - a. Profile Avatar – Update personal profile avatar or picture.
 - b. Problem solving exercises
 - c. Dashboard, Leaderboard and achievement
 - d. Account settings – Update password or the bio-data
 - e. Help – General help about the entire web application features
2. Administrator:
 - a. Manage user accounts i.e. Change password if user forgets the password
 - b. Reports of the System

System Architecture

The gamified system is designed and developed as a web application hosted on educational institute's own server. The chosen implementation technology makes the web application accessible through internet on any web browsers regardless of type of the operating system.

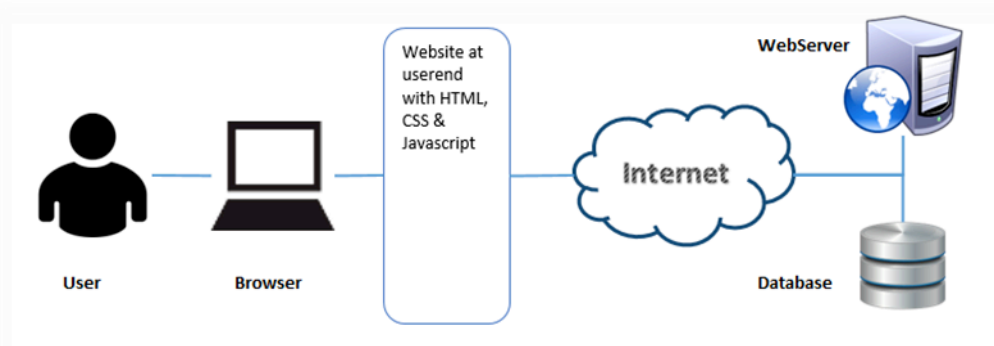


Figure 7. Architecture of Web Application

The web application architecture is not complex and it is mainly divided into two main parts i.e. front-end and back-end separated by the Internet cloud as shown in the Figure 7. The back-end consists of The Database & the web server. The SQL Server is used as a database server to store the user data as well as the exercises data. The webserver is used to host the web application which is responsible for handling all the interaction with the user and with the database. ASP.NET is used as a server side technology coupled with MS SQL Server. The front-end consists of the HTML, CSS, JavaScript & other libraries i.e. JQuery, for handling client side validation and user feedback enabling immediate and swift interaction between the system and the user.

Conclusion

The propose system uses latest technique of gamification applied to ALEPS (an adaptive learning environment for physics problem solving). This gamified system aims to improve student's engagement and motivation. Gamification indirectly prompts to get more knowledge and skills with its direct effect on engagement and motivation [3] and it will eventually be helpful for improving problem solving skills which the ALEPS system is designed for. The system covers three basic areas which are addressed by games i.e. Cognitive, Social and Emotional, where leaderboard element is used to address social satisfaction; Coins and Levels covering the motivational and cognitive aspects respectively. Our next step would be to test this system with the students in order to measure the effectiveness and the impact of the gamification. After the experimental study and based on its results we would reflect towards incorporating more gamification elements to enhance gamification experience such as forum for group discussions and real time chat component and social media that will cover social aspect in better manner and can lead to collaborative learning among students. We are also considering about including mini games focused on basic knowledge of physics such as equations, formulas, symbols and units.

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