Gamified Approach to Database Normalization

Kavisha Duggal  
Asst. Professor of Lovely Professional University  
Jalandhar Punjab, India

Anukool Srivastav  
Student of Lovely Professional University  
Punjab, India

Satvinder Kaur  
Student of Lovely Professional University  
Punjab, India

ABSTRACT
This paper explores how gamification can be applied in learning the normalization concepts in database. Modeling the concept with game challenges improves the learning. The model consists of different levels; each level corresponding to a normal form. The levels are further divided into stages. On crossing each stage, the student (player) would get points depending on the difficulty level. The gamification provides positive effect; however, the effects are greatly dependent on the context in which the gamification is being implemented, as well as on the users using it. A good database design depends on tools required to minimize redundancy and anomalies, preserve known functional dependencies, prevent spurious information from emerging, and identifying keys. This proposed model will make learning normalization more interactive and easier.

General Terms
Database Normalization, Gamification in education, Virtual Learning Environments, game mechanic

Keywords
Gamification, Normalization, E-learning, database normal forms, computer education

1. INTRODUCTION
Games and game-like elements have begun to invade the real world. Gamification is the use of game thinking, game mechanics, game dynamics and frameworks in a non-game context in order to engage users, solve problems, improve user experience, and promote desired behaviours. In simpler words, gamification is simulated learning[3]. Gamification is a recently coined concept referring to design that affords gracefulness into a non-game activity. Gamification is an emerging technique that refers to the use of digital game design techniques and video game elements to solve non-game problems, such as business and social impact challenges [2]. It is applicable to a number of areas including business applications, education, training etc. The primary goals of gamification are to tap into the psychology of motivation to both improve user interaction and interest. The ‘gamification’ concept is increasingly taken over in business, in education, health-care and other public-good oriented professions, and, consequently, in academic research as well. This upsurge is accompanied by animated debates and blazing criticism, currently situated mainly in opinion articles and in conference venues[3]. A frequently used model for gamification is to equate an activity in the non-game context with points and have external rewards for reaching specified point thresholds. One significant problem with this model of gamification is that it can reduce the internal motivation that the user has for the activity, as it replaces internal motivation with external motivation. If, however, the game design elements can be made meaningful to the user through information, then internal motivation can be improved as there is less need to emphasize external rewards.

2. GAMIFICATION IN EDUCATION
Gamifying education can be beneficial for both learners and teachers. Intuition suggests that gamification may be able to motivate students to learn better and to care more about studies. Making the case for gamification, however, requires more than intuition. We must clearly define what is meant by gamification, evaluate it for its benefits and drawbacks, explore current implementations and future possibilities, and better understand the theoretical rationale behind gamification [5]. This will allow us to create effective interventions rather than guessing in the dark by adding game elements, such as rewards, leader boards etc., in a syllabus the learning process can become a more joyful experience. Gamification gives a more dynamic character to education and promotes lifelong learning. As reported on the web site of Wired UK, this approach is being applied for example in Code academy, a social learning platform dedicated to programming [8].

In this paper we define key design goals and propose a model of a normalization aimed at computer database education, which includes (1) structure of the platform, (2) concept of gamification-driven normal forms progress, (3) basic platform functionalities, and (4) methodology of implementation [6]. A new gamifying is being developed, which will eventually serve as a proof of concept for the design proposed here. Nevertheless, conceptualizing gamification [2] in the manner presented here allows us to connect the concept to the literature on motivational affordances in IS research, and further, break down the studies reviewed herein.
3. NOMENCLATURE EQUIVALENCY OF TRADITIONAL AND GAMIFIED APPROACH FOR NORMALIZATION[2]

![Diagram showing traditional vs. gamified approach]

4. PROPOSED NORMALIZATION DESIGN METHODOLOGY

According to the methodology for reaching to next level students need to complete on each preceding level by completing all the stages. Each level of game is equivalent to a normal form.

![Diagram showing normalization levels]

5. GAMIFICATION APPROACH FOR NORMAL FORMS

5.1 Gamifying 1NF (Level 1):

This form requires any duplication of columns in the same table to be removed. Then separate tables will be developed for each entity of related information and each identified with a primary key. A primary key is a unique identifier for each record, creating a column for your primary key helps eliminate redundancy of entities within a table. This problem can be gamified by dividing it into different stages according to the level of redundancy.

![Diagram showing different stages for Level 1]

5.1.1. Stage 1: (Easy Level)

In this level students will be given generalized tables like (student, customer, order etc.) that contain less redundancy means that table can be normalized by decomposition into two tables. Consider an example of CUSTOMER relation that is in un-normalized form (contains redundancy due to multivalued attributes).

<table>
<thead>
<tr>
<th>Table 1.1: Un-normalized Table Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer ID</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>123</td>
</tr>
<tr>
<td>456</td>
</tr>
<tr>
<td>789</td>
</tr>
</tbody>
</table>

Above table can be decomposed into following two tables to remove the redundancy.
5.1.2 Stage 2: High level
In this level students will be given tables that contain more redundancy means that table need to be normalized by decomposition into at least three tables.

Example Table “Company” that is not normalized:

Table 2.1: Company table

<table>
<thead>
<tr>
<th>Name</th>
<th>Pers. ID</th>
<th>Dept. No.</th>
<th>Dept. Name</th>
<th>Project No.</th>
<th>Project Name</th>
<th>Job in Project</th>
<th>Salary/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>A S</td>
<td>1</td>
<td>1</td>
<td>Europe</td>
<td>5,7,8</td>
<td>Soap, Pasta, Olive Oil</td>
<td>Analysis, Leader, Marketing</td>
<td>13,18,15</td>
</tr>
<tr>
<td>S K</td>
<td>1</td>
<td>2</td>
<td>USA</td>
<td>5,8</td>
<td>Soap, Olive Oil</td>
<td>Leader, Leader</td>
<td>18,18</td>
</tr>
</tbody>
</table>

Table 2.2: Employees table

<table>
<thead>
<tr>
<th>Name</th>
<th>Pers. ID</th>
<th>Dept. No.</th>
<th>Dept. Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>A S</td>
<td>1</td>
<td>1</td>
<td>Europe</td>
</tr>
<tr>
<td>S K</td>
<td>1</td>
<td>2</td>
<td>USA</td>
</tr>
</tbody>
</table>

Thus in company table the level of redundancy is high and require more effort of student. So the points /score for successful decomposition will be high (like 10 points). Once all the stages of Level 1 will be completed student will be moved to next level 2.

5.2 Gamifying 2NF (Level 2):
Please in 2NF no non-prime attribute should be functionally dependent on a part of a candidate key that means we have to remove any of the partial dependency. So to gamify the 2NF we need to perform following steps.

i. First student need to identify the candidate (or primary) keys.

ii. Once the candidate keys are known then table will be decomposed.

iii. In decomposition student need to conform that one decomposed tables must include primary key and attributes that are fully functional dependent on that primary key and other decomposed table will include remaining attributes that are not dependent.
EXAMPLE:

Table 3: Sample example of Level 2 ‘Client Rental’ Table

<table>
<thead>
<tr>
<th>Client No</th>
<th>PropertyNo</th>
<th>cName</th>
<th>pAddress</th>
<th>rentStart</th>
<th>rentFinish</th>
<th>Rent</th>
<th>ownerNo</th>
<th>oName</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR76</td>
<td>PG4</td>
<td>Akash</td>
<td>Jalandhar</td>
<td>1-Jan-14</td>
<td>31-Jan-15</td>
<td>350</td>
<td>CO40</td>
<td>Ram</td>
</tr>
<tr>
<td>CR76</td>
<td>PG16</td>
<td>Akash</td>
<td>Delhi</td>
<td>1-Feb-14</td>
<td>1-Mar-14</td>
<td>450</td>
<td>CO50</td>
<td>Mohan</td>
</tr>
<tr>
<td>CR56</td>
<td>PG4</td>
<td>Nikhil</td>
<td>Jalandhar</td>
<td>1-Feb-13</td>
<td>31-Mar-13</td>
<td>350</td>
<td>CO40</td>
<td>Ram</td>
</tr>
<tr>
<td>CR56</td>
<td>PG36</td>
<td>Nikhil</td>
<td>Ludhiana</td>
<td>1-Mar-13</td>
<td>1-May-13</td>
<td>375</td>
<td>CO50</td>
<td>Mohan</td>
</tr>
<tr>
<td>CR56</td>
<td>PG16</td>
<td>Nikhil</td>
<td>Delhi</td>
<td>1-Apr-14</td>
<td>1-May-13</td>
<td>450</td>
<td>CO50</td>
<td>Mohan</td>
</tr>
</tbody>
</table>

Figure 5: First Normal Form ‘Client_Rental’ Table’s Functional dependencies

After the decomposition through 2NF the ClientRental table have the following tables: - Client (clientNo, cName), Rental (clientNo, propertyNo, rentStart, rentFinish), PropertyOwner (propertyNo, pAddress, rent, ownerNo, oName)

Table 3.1: Client

<table>
<thead>
<tr>
<th>Client No</th>
<th>cName</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR76</td>
<td>Akash</td>
</tr>
<tr>
<td>CR56</td>
<td>Nikhil</td>
</tr>
</tbody>
</table>

Table 3.2: Property Owner

<table>
<thead>
<tr>
<th>PropertyNo</th>
<th>pAddress</th>
<th>Rent</th>
<th>ownerNo</th>
<th>oName</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG4</td>
<td>Jalandhar</td>
<td>350</td>
<td>CO40</td>
<td>Ram</td>
</tr>
<tr>
<td>PG16</td>
<td>Delhi</td>
<td>450</td>
<td>CO50</td>
<td>Mohan</td>
</tr>
<tr>
<td>PG36</td>
<td>Ludhiana</td>
<td>375</td>
<td>CO50</td>
<td>Mohan</td>
</tr>
</tbody>
</table>

Table 3.3: Rental

<table>
<thead>
<tr>
<th>clientNo</th>
<th>PropertyNo</th>
<th>RentStart</th>
<th>RentFinish</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR76</td>
<td>PG4</td>
<td>1-Jan-14</td>
<td>31-Jan-15</td>
</tr>
<tr>
<td>CR76</td>
<td>PG16</td>
<td>1-Feb-14</td>
<td>1-Mar-14</td>
</tr>
<tr>
<td>CR56</td>
<td>PG4</td>
<td>1-Feb-13</td>
<td>31-Mar-13</td>
</tr>
<tr>
<td>CR56</td>
<td>PG36</td>
<td>1-Mar-13</td>
<td>1-May-13</td>
</tr>
<tr>
<td>CR56</td>
<td>PG16</td>
<td>1-Apr-14</td>
<td>1-May-13</td>
</tr>
</tbody>
</table>
5.3 Gamifying 3NF (Level 3):-
In 3NF, no non-prime attribute should be functionally dependent on a set of non-prime attributes[6]. So we have to remove the transitive dependency among the attributes. To gamify the 3NF we need to perform following steps.

i. Provide set of functional dependency between the attribute so that transativity dependency an easily be identified.

ii. Now with the help of FD (Functional dependency the student can decompose the table easily).

Example:
In above ClientRental’ table after 2NF to transform the PropertyOwner relation into 3NF we must first remove this transitive dependency by creating two new relations called PropertyForRent and Owner. The new relations have the form.

\[
\begin{array}{|l|l|l|l|}
\hline
\text{PropertyNo} & \text{pAddress} & \text{rent} & \text{ownerNo} \\
\hline
\text{PG4} & \text{Jalandhar} & 350 & \text{CO40} \\
\text{PG16} & \text{Delhi} & 450 & \text{CO50} \\
\text{PG36} & \text{Ludhiana} & 375 & \text{CO50} \\
\hline
\end{array}
\]

\textbf{Table 4.2: Owner 1}

<table>
<thead>
<tr>
<th>OwnerNo</th>
<th>oName</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO40</td>
<td>Ram</td>
</tr>
<tr>
<td>CO50</td>
<td>Mohan</td>
</tr>
</tbody>
</table>

3NF: Decomposition of Property_Owner table

5.4 Gamifying 4NF (Level 4)
In 4NF we have to remove multi-valued dependencies in tables, so user first need to identify multivalued dependency in given table and then decompose it.

\[
\begin{array}{|l|l|}
\hline
\text{Car} & \text{Color} \\
\hline
\text{Mustang} & \text{Red} \\
\text{Mustang} & \text{White} \\
\text{Mustang} & \text{Blue} \\
\text{Cirrus} & \text{Red} \\
\text{Cirrus} & \text{Green} \\
\hline
\end{array}
\]

\textbf{Table 4.4: Car color table}

\textbf{Table 4.5: Car Engine table}

\[
\begin{array}{|l|l|}
\hline
\text{Car} & \text{Engine} \\
\hline
\text{Mustang} & \text{F3.2L} \\
\text{Mustang} & \text{F4.5L} \\
\text{Cirrus} & \text{C2.1L} \\
\text{Cirrus} & \text{C3.0L} \\
\hline
\end{array}
\]

The primary identifier is [Car, Color, and Engine]. None of the attributes are dependent on any of the other attributes — thus, there is no partial key dependency or transitive dependency. The MVDs (multi-valued dependencies) in this case can be fixed by breaking up the original table into two tables.
6. GAMIFIED EVALUATION – IMMEDIATE RESULTS
Evaluation will be done stage by stage and on the completion of the level. The evaluation of the each stage will be based on work done by each student at different stages. For correct evaluation of each set of relation given to the students a predefined normalized form will be used to compare the both form will be used to compare the both values [6]. At beginning the user will be given choice to selection the type of database they want to play for example Student, Customer, Employees, and Sales etc.

<table>
<thead>
<tr>
<th>Column1</th>
<th>Column2</th>
<th>Column3</th>
<th>Column4</th>
</tr>
</thead>
<tbody>
<tr>
<td>……</td>
<td>……</td>
<td>………</td>
<td>…</td>
</tr>
<tr>
<td>……</td>
<td>……</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>………</td>
<td>……</td>
<td>…</td>
<td>…</td>
</tr>
</tbody>
</table>

If the decomposition of this relation consists of following relations then evaluation will be based on the attributes selected by the student that will be compared with the available original decomposition of table.

<table>
<thead>
<tr>
<th>Column1</th>
<th>Column2</th>
<th>Column3</th>
</tr>
</thead>
<tbody>
<tr>
<td>……</td>
<td>………</td>
<td>………</td>
</tr>
<tr>
<td>……</td>
<td>………</td>
<td>………</td>
</tr>
<tr>
<td>………</td>
<td>………</td>
<td>………</td>
</tr>
</tbody>
</table>

7. FUTURE SCOPE
The next step of our research will be to test how the platform works in a real educational environment. The proposed model for the normalization can be implemented by using a high level language. So as a future work we have to design new methods to automate the normalization with different levels, and also develop the tools to enable them to create and modify the gamified learning experiences easily, making the underlying technological infrastructure transparent. Unsupervised scoring/Points systems (Goldberg & Song, 2004) may also be an interesting solution to this problem, and response-driven feedback approaches (Fernandez Aleman, Palmer-Brown & Jayne, 2011) can help us to produce meaningful and rapid feedback.

Furthermore this model can be enhanced for advanced normal forms like BCNF, 5NF etc. to nomalize them using gamification.

8. CONCLUSION
The model proposed here for the normalization using gamification is one of the modern concepts. It aims not only to improve student motivation but also encourage them to participate in various activities of learning, they could otherwise neglect, like learning from instructional materials, practicing coding, taking part in database competitions and help them to learn normalization with fun.

This study also suggests that evening out challenge distribution over the term and making them fairly rewarded might significantly improve student participation and performance rather than learning normalization concepts from books. Students seem to score better with the gamified version of the concept and grade differences between them seem to decrease. For future work we would like to further study the impact of our approach over student outcomes and perform a formal engagement evaluation.

9. ACKNOWLEDGMENTS
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10. REFERENCES
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