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# Design and Development of Learn Your Way Out: A Gamified Content for Basic Java Computer Programming

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**Abstract**

Learning computer programming requires problem-solving skills, coding skills and algorithmic skills which are complex and difficult to master. Computer programming is difficult because of its essence in creating a solution that requires translating it in a language understood only by the computer. This poses barriers like anxiety, panic, stress, grief and frustration to novice programmers. The purpose of this study was to design and develop a gamified content for selected topics of basic Java computer programming for freshman college students of Mindanao State University Tawi-Tawi College of Technology and Oceanography. The game follows the Player-Centered, Iterative, Interdisciplinary and Integrated framework. The idea of using Gamification was adopted in the development of the gamified content. The game was evaluated using Octalysis by seven subject experts from the Institute of Information and Communications Technology. The overall rating of the game resulted to have proper motivation for Gamification.



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## 1. Introduction

In recent years, there has been an increasing interest in programming education around the world [1]. The continuous increase and development of technology has generated a high demand for [2]. Programming skills are needed as a core competency for computer courses (e.g., Computer Science, Information Technology, and Information Systems) [3,4,5]. Learning computer programming requires problem-solving skills, coding skills and algorithmic skills which are complex and difficult to master [6]. Unfortunately, many college students have trouble in learning these skills.

In the Philippines, according to JobStreet.com [7], programmers are the highest paid professionals. Unfortunately, students wanting to learn how to program are having difficulties. Students undergo rigorous laboratory exercises and requirements to learn computer programming. Learning the subject is needed to survive higher applications of programming like binary numbers, syntaxes, algorithms, logic circuits, data structures, system analysis and design and other problems [8]. According to Bringula, Aviles, Batalla, Borebor, & Uy [9], computer programming is difficult because of its essence in creating a solution that requires translating it in a language understood only by the computer. This poses barriers like anxiety, panic, stress, grief and frustration [10,11] to novice programmers.

Recent researches used the idea of Gamification, an emerging technology and considered a trend that is at the peak performance and a key trend in the information technology business that was represented in the Gartner Hype Cycle [12] in 2011 produced by Gartner Incorporated. Many researches used Gamification like Bittner and Shipper [13], and Hamari [14]. They used Gamification in commerce to engage users and promote an increase in trading activity; Laskowski and Badurowicz [15], Lui [16], and Barata et al. [17] used Gamification to promote better learning outcomes in schools. There researches have observed that Gamification can be an enticing method or strategy to promote student engagement [18] in learning computer programming.

So, in this study, it is aimed to design and develop a gamified approach on the basics of Java computer programming that will engage students in learning the basic topics of Java computer programming. The game Learn Your Way Out was developed to serve as a supplementary teaching tool for students taking computer programming.

## 2. Review of related literature

This section presents various related literatures and related studies critically reviewed by the researcher integrating game elements used for design and development of this study.

### *2.1. Game elements*

Game elements are considered in designing a gamified content. Many researchers [19,20,21,22] have different representations of game elements. Flatla, et. al., [20] identifies four game elements: (1) Challenge. The game needs to have something a player engage into to gain rewards when accomplished. (2) Theme. Putting the whole game in a fantasy setting, letting the player experience an imaginary world or feeling. (3) Reward. Reinforcement of the accomplished task of the players. This may include sound or simple animations. (4) Progress. This is in a way another form of reward in the game where the player moves to another level where more challenges and rewards await. This could also be represented as high scores in the game.

Some like Pavlas, et. al., [19] and Bedwell, et. al., [21] have identified their game elements based on the work of Wilson et al [2]. These elements are (1) Adaption, where level of difficulty of the game is dependent on the skill of the player [23]; (2) Assessment. The scores obtained in the game [24]; (3) Challenge, which is the level of difficulty of the game in order to achieve its goals [25,26]; (4) Conflict. This is where the story of the game revolves [27]; (5) Control. This is giving your players the manipulate the elements of the game bound by the game rules and mechanics [25]; (6) Fantasy. The imaginary parts of the game. It can be the world itself, the characters or even scenarios [25,28]; (7) Interaction (equipment). The ability of the players to change or manipulate the game [23]; (8) Interaction (interpersonal) is the face-to-face interaction between payers in real life and not just in the game world [27]; (9) Interaction (Social). This is the interaction of the players that happen in-game [23]; (10) Language /Communication. A part of the game the game and the player would be able to understand each other [26]; (11) Location. This refers to the physical or digital world the game takes place. This can be a real world, imaginary or augmented [26]; (12)

Mystery. This is the unknown parts of the game that evoke curiosity to the players [25]; (13) Players. Objects or people that are included in the story of the game [26].

Others, like Kapp [22] presented game elements as (1) Mystery. The inconsistencies of the game that arouses the players' curiosity. Kapp refers to this as the "what happened and why" element; (2) Action. This is what the players are doing in the game when it starts; (3) Challenge. This is how to accomplish the game based on the tasks given to the player. This in turn gives incentives or rewards to the player done; (4) Being at risk. Loosing something earned from challenges in-game when mistakes are made is what keeps players engaged. (5) Uncertainty. when the player does not know what will happen next, it raises suspense, intrigue, and enables them to focus their attention om the task in the game; (6) Opportunity for mastery. When players can accomplish in-game tasks faster or more efficient, this is what many players want to achieve in the long run. Even if the players loose at some point, them being master of the game is always evident, in the form of badges, or high scores in leaderboards; (7) Progress. Badges and high scores in leaderboards best represent the progress of players in-game; (8) Emotional content. Engage the players by letting them feel emotions during game play. This can range from frustrations, which can sometimes lead to the player to push on, anger, or happiness. For this study, game elements represented by Flatla, et. al. [20] was used in the development of Learn Your Way Out.

## 3. Methodology

The design and development of the game follows a structure based on the on the Player-Centered, Iterative, Interdisciplinary and Integrated framework of Vanden Abeele et, al. [29] illustrated in Fig. 1. First level starts with identification of the topics to be gamified. Data gathered from programing instructors like basic topics on basic programming arithmetic, branching statements, and loops were integrated in the game since these topics are the basic knowledge needed as foundation and used for higher programming applications. After determining the topics, game concept analysis was made to identify the main objective of the game, the rules and mechanics and the game elements to be integrated in the game. Second level started with the creation of a storyboard. The storyboard is a system and application design that contains details of the programming, audio script, and detailed description of elements like text, video, graphics and animation [30]. Once a storyboard is planned out the next step is to create a paper prototype to provide a lifelike miniature version of the design and an initial game design document which contains the entire events that can occur in the game (i.e. game mechanics, game flow, story, levels, characters). And lastly, the game development, Learn Your Way Out was developed using HTML5.

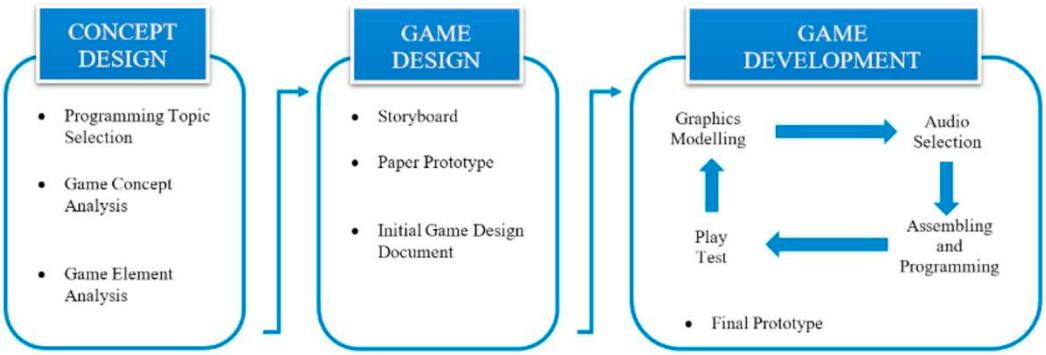


Fig. 1. Game design and development concept design.

The game was developed using HTML5 because it supports for full screen game adjustments and allows users to play games without the annoying message "Plugin required" [31]. Applications and games created in HTML5 can run natively on any device through a browser. Also, it allows developers to use other cutting edge features such as WebGL (a graphic library that allows 3D rendering for 3D games), audio APIs (Application Programming Interface) and with

the connection of CSS3 (Cascading Style Sheet Version 3) can support transitions, animations, hardware-acceleration, media playback and local storage of application data [32].

The Octalysis framework in Fig. 2 was used to evaluate whether the game has a good motivation of gamifying a non-gamified content. It evaluates Gamification based on the eight (8) core drives:

- *Epic meaning and calling.* This refers to the need to participate in something bigger than just yourself.
- *Development and accomplishment.* This is about motivating people because they feel that they are improving,
- they are leveling up and achieving mastery.
- *Empowerment of creativity and feedback.* This is the core drive that motivates people to incorporate their
- creativity, try different combinations and strategies, seek feedback and adjust.
- *Ownership and possession.* This is the primary core drive that motivates people to accumulate possessions,
- improve them, protect them and get more of them.
- *Social influence and relatedness.* This refers to the activities motivated by the influence of other people (e.g.,
- by what other people do or think).
- *Scarcity and impatience.* This is what motivates people to want something they cannot have (e.g., because it is not immediately or easily obtainable).
- *Unpredictability and curiosity.* This refers to the willingness to discover the unknown outcome and involves chance.
- *Loss and avoidance.* This refers to the motivating factors that help people avoid situations they do not want to happen (e.g., to die in a game).

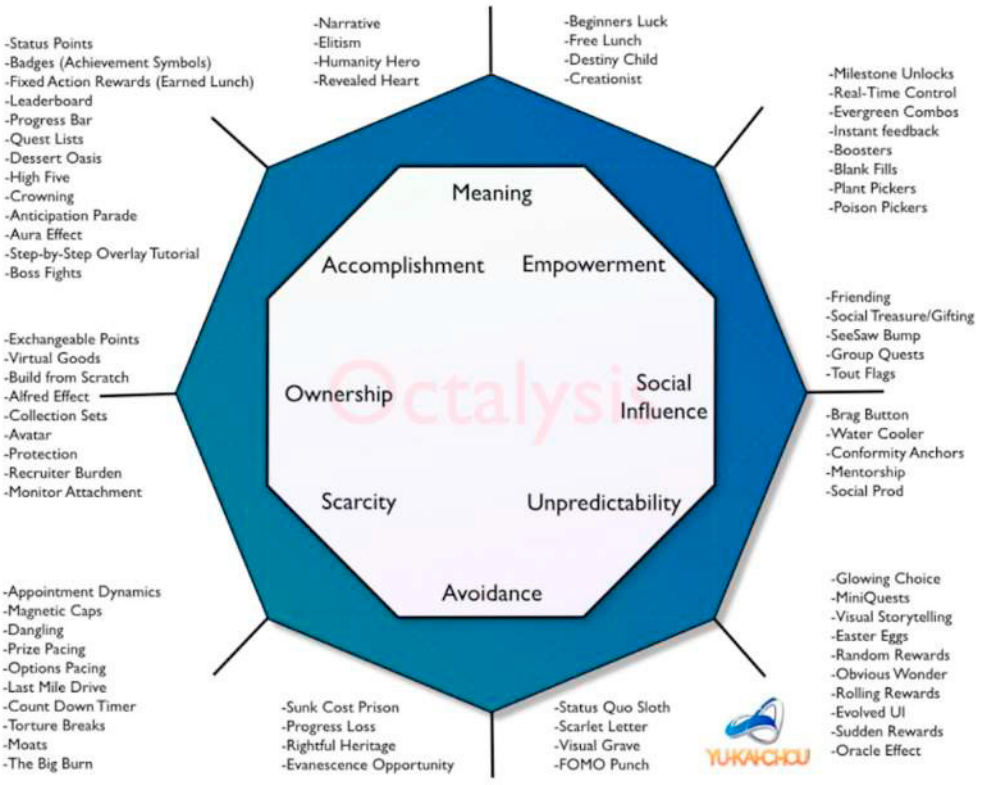


Fig. 2. Octalysis framework: 8 core drives.

Core drives on the right side of the Fig. 2 are represented as right brain core drives which are related to creativity, self-expression, and social aspects. The core drives on the left side of Fig. 2 are represented as left brain core drives which are related to logic, calculations, and ownership.

Right brain core drives represent intrinsic motivators: users do not need goals and rewards to be creative; the activity itself is rewarding on its own. On the other hand, left brain core drives represent extrinsic motivators: users are motivated because they want to obtain something. According to Yu-Kai Chou [5], it is much better to create game experiences that motivate the right brain core drives where games are fun and rewarding that users are continuously engaged in the activity.

Another element to note within Octalysis is that the top core drives are considered as very positive motivators called White Hat Gamification, while the bottom core drives are considered as negative motivators called Black Hat Gamification. The representation of negative motivators in Black Hat Gamification does not mean that the application of Gamification is necessarily bad; these are just motivators. A good Gamification must consider all 8 core drives on a positive and productive activity.

## 4. Results and discussions

In the development of the game, many difficulties were encountered. The first issue that comes in mind, the game must be accessible with or without an internet connection for students to use the game anytime anywhere. Second, game developers must always consider the resolution size to maintain design stability. This difficulty poses a challenge not only for game developers but for software developers as well. Third, Using Gamification as a strategy to engage students, another challenge that can be encountered in development is conceptualizing a game with proper game elements to engage users in using the game. Not all games are fun and engaging, proper game elements is a must to achieve a satisfied and engaged user. Lastly, after a finished prototype, the game must be tested first by what developers call “Beta testers”. These testers test the game for bugs, functionality and of course effective engagement and satisfaction for other users when the game is set for deployment. Given these difficulties encountered by the researcher, designing and developing a game is not an easy task. After development, the game is now ready for play test (See Fig. 3).

The results of the quantitative analysis of the data were through the play test of the seven subject experts. These experts are identified as programming instructors teaching the computer programming subject. During the testing of the gamified content each subject expert where asked to play the game. An allotted time of fifteen (15) minutes or more were given until each expert stop playing and was asked to rate the game using the Octalysis Gamification framework.


Fig. 3. In game screenshots of Learn Your Way Out.

### *4.1. Octalysis score*

Seven subject experts rate the game based on the core drives visible in the octagon. Subject experts are identified as programming instructors teaching the computer programming subject. In order to come up with an Octalysis score, a number between zero (0) and ten (10) was assigned; this number was squared to get the core drive score. Final Octalysis score was represented by the sum of all core drive scores.

The Octalysis scores of 6 out of 7 subject experts showed that Learn Your Way Out has a good motivation for Gamification (See Table 1); this means it has a balanced extrinsic and intrinsic motivations for Gamification. However, the result of one subject expert revealed a white hat Gamification; this means that users feel great and empowered but they do not have a sense of urgency to commit to the desired actions. The left and right brain core drives also appeared to be balanced on all subject experts.

Table 1. Octalysis scores of subject experts.

| Subject Expert | Epic meaning and calling | Development and accomplishment | Empowerment of creativity and feedback | Ownership and possession | Social influence and relatedness | Scarcity and impatience | Unpredictability and curiosity | Loss and avoidance | Octalysis Score |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 8 | 10 | 8 | 8 | 8 | 10 | 10 | 10 | 656 |
| 2 | 10 | 10 | 10 | 10 | 10 | 8 | 8 | 8 | 692 |
| 3 | 6 | 8 | 6 | 6 | 8 | 8 | 4 | 6 | 352 |
| 4 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 800 |
| 5 | 4 | 8 | 6 | 2 | 2 | 2 | 4 | 2 | 148 |
| 6 | 8 | 10 | 10 | 10 | 8 | 8 | 10 | 10 | 692 |
| 7 | 8 | 8 | 8 | 8 | 6 | 8 | 8 | 8 | 484 |

For subject Expert 1, the total Octalysis score of the game is 656. All core drives are on the average almost close to each other. The left and right brain core drives are balanced. Also, motivators representing white hat and black hat Gamification are balanced as well.

For subject Expert 2, the total Octalysis score is 692. The left and right brain core drives are balanced. Subject expert experience is slightly focused on white hat Gamification but still presents as balanced to black hat Gamification. The Octalysis score of subject Expert 3 is 352, slightly lower than the first two subject experts. The left and right brain core drives are balanced. Also, motivators representing white hat and black hat Gamification are balanced as well. The Octalysis score of subject Expert 4 is 800, a perfect score for all core drives in the framework. This means that the left and right brain and white hat and black hat Gamification are all equally balanced.

For subject Expert 5, the total Octalysis score is 148 which is lower than subject Expert 3. Having an even lower score than other evaluators does not mean that the elements used for Gamification is bad; this just means that it needs a little improvement. The left and right brain core drives are balanced. Subject expert experience is heavily focused on white hat Gamification, which means users feel great and empowered. The drawback is that users do not have a sense of urgency to commit to the desired actions. It must have a slight implementation on light black hat techniques to add a bit more thrill to the experience.

For subject Expert 6, the total Octalysis score is 692. All core drives are on the average almost close to each other. This is almost similar to the experience of subject Expert 1. The left and right brain core drives are balanced. Also, motivators representing white hat and black hat Gamification are balanced as well.

The Octalysis score of subject Expert 7 is 484. All core drives are on the average almost close to each other. This is similar to the experience of subject Expert 1 and 6. The left and right brain core drives are fairly balanced. Also, motivators representing white hat and black hat Gamification are balanced as well.

## 5. Conclusions and recommendations

Learn Your Way Out was developed in this study. It gamified the selected non-gamified topics in basic Java computer programming. The Octalysis framework showed that the game elements used were proven deemed to be proper elements in the game.

Design and development of the game was successful, and evaluation rated by subject experts resulted to have a great motivation for the Gamification of the non-gamified topics. Left Brain and Right Brain Core drives resulted to be balanced with the game elements integrated in the game. Ratings also resulted to be positively favoured to a White Hat Gamification which according the analysis of the Octalysis framework means that game elements used resulted to be positive motivators for users.

Game users were amazed in using the Learn Your Way Out game. Its development is still in its simplistic form and still have room for many improvements. Updates can still be made in the forms of game elements, additional game mechanics and integration of other topics aside from the topics selected in this study. For future studies, researchers could explore the use of the game in connection to student engagement as supplementary tool for classroom learning in teaching students the fundamentals of computer programming.

## References


[1] Kanemune, S., S. Shirai, and S. Tani. (2017) "Informatics and Programming Education at Primary and Secondary Schools in Japan." *Olympius in Informatics* **11**: 143-150.

[2] Wilson, K.A., W.L. Bedwell, E.H. Lazzara, E. Salas, C.S. Burke, J.L. Estock, and C. Conkey. (2009) "Relationships Between Game Attributes and Learning Outcomes: Review and Research Proposals." *Simulation & Gaming* **40 (2)**: 217-266.

[3] Verdú, E., L.M. Regueras, M.J. Verdú, J.P. Leal, J.P. de Castro, and R. Queirós. (2012) "A Distributed System for Learning Programming On-Line." *Computers & Education* **58 (1)**: 1-10.

[4] Hwang, W.Y., R. Shadiev, C.Y. Wang, and Z.H. Huang. (2012) "A Pilot Study of Cooperative Programming Learning Behavior and its Relationship with Students' Learning Performance." *Computers & Education* **58 (4)**: 1267-1281.

[5] Fessakis, G., E. Gouli, and E. Mavroudi. (2013) "Problem Solving by 5–6 Years Old Kindergarten Children in a Computer Programming Environment: a Case Study." *Computers & Education* **63**: 87-97.

[6] Wang, Y., H. Li, Y. Feng, Y. Jiang, and Y. Liu. (2012) "Assessment of Programming Language Learning Based On Peer Code Review Model: Implementation and Experience Report." *Computers & Education* **59 (2)**: 412-422.

[7] JobStreet.com. (2015) "The 2015 Jobs and Salary Report for Fresh Graduates". Available from: http://jobstreet.com.ph/career-resources/2015-jobs-salary-report-fresh-graduates. [Accessed 03rd March 2018].

[8] Codilan, R.R. (2017) "Factors Affecting the Performance of Computer Science Students in Programming Subjects as of 2016–2017." *Imperial Journal of Interdisciplinary Research* **3 (4).**

[9] Bringula, R.P., A.D. Aviles, M.Y.C. Batalla, M.T.F. Borebor, and M.A.D. Uy. (2017) "Factors Affecting Failing the Programming Skill Examination of Computing Students." *International Journal of Modern Education and Computer Science* **9 (5): 1.**

[10] Rogerson, C., and E. Scott. (2010) "The Fear Factor: How it Affects Students Learning to Program in a Tertiary Environment." *Journal of Information Technology Education: Research* **9**: 147-171.

[11] Shuhidan, S., M. Hamilton, and D. D'Souza. (2009) "A Taxonomic Study of Novice Programming Summative Assessment", in *Proceedings of the Eleventh Australasian Conference on Computing Education,* Australian Computer Society, Inc, **95**: 147-156.

[12] Gartner Incorporated. (2011) "Gartner Hype Cycle 2011." Available from: https://www.gartner.com/en/documents/1754719. [Accessed 10th September 2017]

[13] Bittner, J.V., and J. Schipper. (2014) "Motivational Effects and Age Differences of Gamification in Product Advertising." *Journal of Consumer Marketing*. **31(5)**: 391-400.

[14] Hamari, J. (2017) "Do Badges Increase User Activity? A Field Experiment on the Effects of Gamification." *Computers in Human Behavior* **71**: 469-478.

[15] Laskowski, M., and M. Badurowicz. (2014) "Gamification in Higher Education: A Case Study", in *Make Learn International Conference*. **25**: 971-975.

[16] Lui, S. (2014) "Use of Gamification in Vocabulary Learning: A Case Study in Macau", in *4th CELC Symposium Proceedings.* 90-97.

[17] Barata, G., S. Gama, J. Jorge, and D. Gonçalves. (2013) "Improving Participation and Learning With Gamification", in *Proceedings of the First International Conference on Gameful Design, Research, and Applications.* ACM. pp.10-17.

[18] Hamari, J., J. Koivisto, and H. Sarsa. (2014) "Does Gamification Work?-A Literature Review of Empirical Studies on Gamification." *HICSS* **14 (2014)**: 3025-3034.

[19] Pavlas, D., W. Bedwell, S.R. Wooten, K. Heyne, and E. Salas. (2009) "Investigating the Attributes in Serious Games That Contribute to Learning", in *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*. Los Angeles, CA, SAGE Publications. **53 (27)**: 1999-2003.

[20] Flatla, D.R., C. Gutwin, L.E. Nacke, S. Bateman, and R.L. Mandryk. (2011) "Calibration Games: Making Calibration Tasks Enjoyable by Adding Motivating Game Elements", in *Proceedings of the 24th Annual ACM Symposium on User Interface Software and Technology.* ACM. pp. 403-412.
[21] Bedwell, W.L., D. Pavlas, K. Heyne, E.H. Lazzara, and E. Salas. (2012) "Toward a Taxonomy Linking Game Attributes to Learning: an Empirical Study." *Simulation & Gaming* **43 (6)**: 729-760.
[22] Kapp, K. (2014) "8 Game Elements to Make Learning More Intriguing." Avalilable from: https://www.td.org/insights/eight-game-elements-to-make-learning-more-intriguing. [Accessed 30th July 2018].
[23] Prensky, M. (2001) *Digital Game-Based Learning*, New York, McGraw-Hill.
[24] Chen, S., and D. Michael. (2005) "Proof of Learning: Assessment in Serious Games." Gamasutra. Available from: http://www.gamasutra.com/features/20051019/chen_01.shtml. [Accessed 9th October 2006].
[25] Garris, R., R. Ahlers, and J.E. Driskell. (2002). "Games, Motivation and Learning: A Research and Practice Model." *Simulation & Gaming* **33 (4)**: 441-467.
[26] Owen, M. (2004) "An Anatomy of Games: A Discussion Paper." *Futurelab.* Avaliable from: http://www.futurelab.org.uk/download/pdfs/research/disc_papers/Anatomy_of_Games_discpaper.pdf. [Accessed 11st September 2006].
[27] Crawford, C. (1984) *The art of computer design,* Berkeley, CA, Osborne/McGraw-Hill.
[28] Habgood, M.P.J., S.E.S. Ainsworth, and S. Benford. (2005) "Endogenous Fantasy and Learning in Digital Games." *Simulation & Gaming* **36 (4)**: 483-498.
[29] Abeele, V.V., B. De Schutter, L. Geurts, S. Desmet, J. Wauters, J. Husson, and D. Geerts. (2012) "P-iii: A Player-Centered, Iterative, Interdisciplinary and Integrated Framework for Serious Game Design and Development." in *Serious Games: The challenge.* Berlin, Heidelberg. Springer. 82-86.
[30] Orr, K.L., K.C. Golas, and K. Yao. (1994) "Storyboard Development for Interactive Multimedia Training." *Journal of Interactive Instruction Development* **6(3)**: 18-31.
[31] Curran, K., and C. George. (2012) "The Future of Web and Mobile Game Development." *International Journal of Cloud Computing and Services Science* **1 (1)**: 25.
[32] Elliott, J.L. (2013) *HTML5 Game Development With Gamemaker,* Packt Publishing Ltd.
[33] Chou, Y.K. (2015) *Actionable Gamification: Beyond Points, Badges, and Leaderboards*, Octalysis Group.