

## AN ANALYSIS OF WINNING STREAK'S EFFECTS IN LANGUAGE COURSE OF “DUOLINGO” \*

DUY HUYNH  
HIROYUKI IIDA

### ABSTRACT

This paper explores the effects of the winning streak on users' motivation and engagement in Duolingo's language course. The winning streak has been used in sport and video games to describe a consecutive number of successful actions and increase players' attention to complete their goal. Similarly, in gamified education system, the winning streak is employed as a game element to boost up motivation of learners. By applying game refinement theory as an assessment method, enjoyment of two user groups in Duolingo is measured to compare. The results indicate that the winning streak can boost up learners' motivation and attention to complete their goals. It also expressed that the winning streak is more significant for advanced learners who are in the high level of milestone than those who are in the low level of milestone.

Keywords: Duolingo, gamified learning platform, game in education, winning streak, game refinement theory, attractiveness, game progress model.'

---

\* Duolingo ® and all other trademarks, service marks, graphics and logos used in connection with the Service are trademarks or service marks of Duolingo or their respective owners, and certain of them are registered with the United States Patent and Trademark Office.

### INTRODUCTION

Duolingo, known as a gamified platform, has become a popular language learning application. It offers 59 different courses across 23 languages for more than 150 million learners (Duolingo). When diving into the popularity of this platform, it is clear that “gamification” has successfully been applied in Duolingo to engage and motivate their users. The term “gamification” is defined as the application of game-based elements into non-game contexts (Deterding et al., 2011). While gamification is gaining ground in some fields such as business, marketing, management and wellness initiatives, its application in education is still an emerging trend. The benefit of game and game-based approaches in education has been investigated since 1980s (Klopfer, 2008; Shaffer, 2006). In recent years, the interest in the gamification topic has rapidly increased. Despite this recent growth, there is a lack of research in the education domain.

To understand the effects of game-based elements in an educational environment, an assessment of gamification was carried out using Duolingo as a testbed (Huynh et al., 2016), with a focus on the main action of learners in the language learning process, i.e., badges obtaining. Hence, the language course structure constructed by a tree of badges was particularly analyzed. Nevertheless, the badge is not a unique game-based element used to gamify Duolingo system, but there are other elements, such as winning streak and leader board. Thus, the present study focuses on other game-based elements. Although there are several game-based elements, we only focus on which elements affecting directly on the motivation of learners. As a result, a winning streak, which is very popular in sport and video games, is a candidate for this study.

## LITERATURE REVIEWS

### RELATED WORKS

We first review some literatures, which relate to the use of game in the educational environment. Unlike game-based learning, which is clearly a game, the essence of gamification is that it occurs in a non-game context. Therefore, it would be possible to apply in such a way that gamification would not change the existing practice of learning, and instead focus on making it more engaging and challenging for student (Scepanovic et al., 2015). There are an increasing number of case studies and researches dealing with gamification in general (Hamari et al., 2014) and in education contexts (Barata et al., 2013). Moreover, in educational games domain, some several models was provided to support in analyzing and designing serious games such as RETAIN (Gunter et al., 2008), 5/10 method (Jeurig et al., 2013), and activity theory-based model of serious games (ATMSG) (Carvalho et al., 2015). While RETAIN and 5/10 method support to design a game with clearly defined learning goals and objectives, ATMSG provides a comprehensive way to investigate, in detail, how a serious game is structured, and uses activity theory as the theoretical background.

Whereas majority of studies report overall positive results of applying game elements into the system and its effects in motivating and engaging learners, our researches aim at maximizing the effectiveness of using games in the education context. To reach our goal, we have to do analysis in some popular educational games in order to figure out the way to improve the entertainment aspect in this domain. Besides, our studies try to apply the game refinement theory (Takeuchi et al., 2014) into various types of serious games domain as an assessment method for our analysis. This theory is a new game theory that concerns about the entertainment aspects by using a game sophistication to measure attractiveness of the game under consideration. In this study, we continue our works from the first study (Huynh et al., 2016) by analyzing the effects of other game-based element in Duolingo that is called “winning streak”.

### WINNING STREAK

The term “winning streak” was initially used in sport (Winning Streak). It refers to a consecutive number of games won, which begins from the third consecutive victory. A winning streak is held not only by an individual, as in tennis, but also by a team. For example, we mention basketball, soccer and hockey. In basketball, a “hot hand” was used to describe a basketball player who had been very successful in scoring over a short period. It was believed that players who make a shot are more likely to hit the next shot than players who miss a shot (Camerer, 1989). Hence, the players, who obtained a winning chain, always keep their streak continue. In other words, a winning streak affects directly to players' attention in order to complete their goal for increasing their performance. Furthermore, a winning streak is also used in video games. For example, in DOTA2, a killing streak is used to increase players' attention to conduct a battle with opponent players. Corresponding to the number of kills, some titles are awarded to players (DOTA 2 – Hero Kills), such as Killing Spree (3 kills), Dominating (4 kills), Mega Kill (5 kills), etc., in order to encourage users to repeat their actions. There are many famous video games using a winning streak in the game play, such as Call of Duty, Cross Fire and League of Legends.

In Duolingo, a winning streak has been used as a measurement of how consistently learners study. A winning streak starts at zero and increases by one as long as learners complete to study their required number of lessons. The winning streak will be reset to zero if the number of studied lessons is missed. However, the learners can keep their streak by using

“streak freeze” which is sold in Duolingo shop. Although we clearly see the effects of a winning streak in some areas such as sport and video game, we are not sure if those effects also happen in gamified systems or serious games. For this reason, in this study, we aim at analyzing the effects of winning streak in a gamified platform by using Duolingo as a testbed. In order to clarify those effects, we make a comparison between two groups of users: those who obtained a winning streak and others who did not obtain.

## THE ANALYSIS OF WINNING STREAK’S EFFECTS

### ASSESSMENT METHOD

We first show a short sketch about game refinement theory which has been proposed by Iida et al. (Takeuchi et al., 2014). This theory concerns optimization from a viewpoint of game designer. Generally, the game attractiveness is evaluated base on users’ performance by using survey or questionnaire. While the game refinement theory shows a particular way to quantity the attractiveness by providing the common measurement – game refinement value, which is derived from a model of ‘game progress’. The ‘game progress’ is twofold, which are known as game speed or scoring rate, and another one is game information progress with a focus on the game outcome. In sport games and video games, game speed has two factors: (1) goal and (2) time or steps to archive the goal. Game information progress represents how certain is the result of the game in certain time or steps. If the outcome is more uncertain, the game will be more interesting. The game refinement theory has been applied in some well-known games in order to measure refinement values of the games under consideration. The refinement values of those games fall into the range from 0.07 to 0.08 (Sutiono et al., 2014; Nossal & Iida, 2014).

Educational games are different from fun games. They are gamified learning platforms, which means that they use game elements to create enjoyment points in learning. In an educational environment, an attempt to complete learning tasks for obtaining rewards is considered as game actions. Therefore, the game speed of educational games is given by

$$\frac{\textit{average\_number\_of\_rewards}}{\textit{average\_number\_of\_tasks}}$$

Now we consider a model of game information progress. Let  $R$  and  $T$  are the average number of rewards and the average number of tasks, respectively. If one knows the game information progress, for example after the game, the game information progress  $x(t)$  will be given as a linear function of time  $t$  with  $0 \leq t \leq T$  and  $0 \leq x(t) \leq R$  by Eq. (1).

$$x(t) = \frac{R}{T}t \tag{1}$$

However, the game information progress given by Eq. (1) is unknown until the end of the game. Hence, a realistic model of game information progress of the game is given by Eq. (2).

$$x(t) = R \left( \frac{t}{T} \right)^n \tag{2}$$

We assume that the parameter would be  $n \geq 2$  in many cases like sport games or video games. Then acceleration of the progress is obtained by deriving Eq. (2) twice. Solving it with  $t = T$ , we have Eq. (3).

$$x''(T) = \frac{Rn(n-1)}{T^n} T^{n-2} = \frac{R}{T^2} n(n-1)$$

(3)

We do not yet know how the game information progress is encoded and transported in our minds. However, it is likely that the acceleration of game information progress is related to the force in mind, which is indicated from Newton mechanics ( $Force = mass \times acceleration$ ). Hence, it is reasonably expected that if the  $\frac{R}{T^2}$  is larger, the game is more exciting, due to the uncertainty of game out come. Therefore, we used the root square of  $\frac{R}{T^2}$  as the game refinement value for considered games (see Eq. (4)).

$$GR = \frac{\sqrt{R}}{T} \quad (4)$$

#### GAME PROGRESS MODEL IN DUOLINGO

In the previous study (Huynh et al., 2016), we mentioned about the use of milestone technique in Duolingo. This technique used to split a big task into smaller tasks in order to help users complete their works easier. Therefore, we consider each milestone in a language course as a sub game and measure the game refinement value for those sub games in this course. In general, the normal users do not study consecutively and they only pay their attentions to getting badges, so that  $R$  in game progress model is an average number of obtained badges. For the average number of learned skills ( $S_k$ ), and  $T$  is the average number of learned lessons ( $L_k$ ) in a milestone  $k$ , the game refinement value of each milestone is measured by Eq. (5).

$$GR_k = \frac{\sqrt{S_k}}{L_k} \quad (5)$$

Actually, there is not only the badge as a reward. A winning streak is an extra reward for users, who always keep their study in progress, which means that they have to finish learning a consistent number of lessons every day. We call the user who obtained a winning streak, a streaking-user while others are normal-users. According to the percentage of streaking-users (see Table 1), obtaining streaks is less important at low level than high level of milestones. Therefore, we apply Eq. (6) in order to measure attractiveness of streak in each milestone. In Eq. (6)  $S_k$  and  $L_k$  denote the average number of learned skills and lessons, where  $i_k$  stand for the importance value of a winning streak, and  $E_k$  stands for the average length of winning streak in a milestone  $k$ .

$$GR_k = \frac{\sqrt{S_k + i_k E_k}}{L_k} \quad (6)$$

The importance value of winning streak expresses the strength of attractiveness cause by the streak in each milestone. Therefore, we calculate it based on the percentage of streaking-users. At high levels, new lessons are not easy for users to be obtained, so that a winning streak is very important for users' engagement at those levels. Hence, the importance value of winning streak accumulated calculates by Eq. (7), where  $i_k$  denotes the importance value of streaks and  $p_k$  stands for the percentage of users who obtained a winning streak in the milestone  $k$ . Although in some case a winning streak is not important, nobody can deny its attractiveness. Therefore the parameter  $i_k > 1$  is reasonable, and the accumulation of  $i_k$  should start from this point.

$$i_k = i_{k-1} + p_k \quad (7)$$

## EXPERIMENT AND DISCUSSION

Duolingo has 150 million users around the world and currently teaches 23 distinct languages. Each language course in Duolingo has different learning material and structure. That means each course is an individual learning environment. Therefore, to see the effects of a winning streak obviously, we selected 2000 users, who enrolled the most popular course – “*English for Spanish Speaker*” (*EFSS*), to collect data. The criterion, which is used to select candidates, is that they must be active on the system within one week before the data collecting date. Because some information fields of users should be kept in secret, so we only collected public information of users. The collected information, which is indicated in user’s profile page of Duolingo, includes a number of skills, length of a winning streak and the languages course. After the data was collected, we analyze the statistics to figure out the percentage of streaking-users (*PoSU*) in each milestone. The statistical results and the importance values of winning streak are calculated as shown in [Table 1](#).

After that, we measured two kind of game refinement (*GR*) values in each milestone in order to evaluate the effects of winning streak by comparing them, which is more attractive between two groups of users. The first group consists of streaking-users and another group contains normal-users. The game refinement values ( $GR_k$ ) of the first group are measured by [Eq. \(6\)](#) while the second group calculated by [Eq. \(5\)](#), and the results are presented in [Table 2](#).

TABLE 1. Percentage of streaking-users (*PoSU*) of each milestone in *English for Spanish Speaker* (*EFSS*)

Milestone ( <i>k</i> )	<i>PoSU</i> (%)	$i_k$
1	14.82	1.15
2	22.60	1.38
3	27.07	1.65
4	29.59	1.95
5	56.84	2.52

TABLE 2. Game refinement values ( $GR_k$ ) in detail of each milestone in *EFSS*

Milestone <i>k</i>	$S_k$	$L_k$	$i_k$	$E_k$	$GR_k$	$GR_k$ (no streak)	Difference	Increase ratio (%)
1	10	39	1.15	2.2	0.090	0.081	0.009	11.11
2	22	95	1.38	6.43	0.058	0.049	0.009	18.37
3	36	171	1.65	21.89	0.050	0.035	0.015	42.86
4	49	252	1.95	47.84	0.047	0.028	0.019	67.86
5	64	321	2.52	59.02	0.045	0.025	0.020	80

[Table 2](#) shows that the difference of *GR*-values between two user groups increases through each milestone. This implies that a winning streak can increase attractiveness in each milestone of *EFSS* at least by 0.009 (see the case  $k=1$  and  $k=2$ ) for streaking-users. The difference of the fifth milestone is 0.02, while the difference between the first and the second milestone are trivial. Let us consider the trend of *GR* values for normal-users. The decrease of game refinement values indicates that the game challenge increases to adapt the advancement of learners’ skill. However, we are not certain that the increase can adapt all learners’ advancement in a course. In high levels, users are required to have a certain level of knowledge in order to pass all lessons in each skill. Therefore, it is more difficult to obtain badges. Someone, who has not enough knowledge to pass lessons at high levels, should practice more to improve their skills. Nonetheless, a badge is not given by reviewing lessons. That is a reason why a winning streak is only the element that can improve users’ motivation

in this case. For this reason, the winning streak is necessary at those levels. It means that a winning streak can improve attractiveness of the game when the challenge increases.

The winning streak becomes more significant for advanced users, who are at high level of milestone, rather than beginners. According to the streaking-users' percentage which increases by each milestone (see Table 1), over 56% users in the fifth milestone keep their study progress by obtaining a winning streak, whereas only 14.82% users do that in the first milestone. Moreover, considering the difference of GR values between two user groups as the effects caused by a winning streak on streaking-users, the winning streak can increase attractiveness up to 80% in the last milestone, but it is less than 20% in two first milestones.

## CONCLUSION

In this study, we have analyzed the effects of a winning streak in Duolingo by using the game refinement theory as an assessment method. This theory shows the particular way to measure the attractiveness of the game under consideration. Based on a game action in an educational environment, we figured out the generalized game progress model for educational games. After that, we have used this model to quantify the attractiveness of considered game-based elements in a language course of Duolingo.

For the experiment, we collected users' data to measure a game refinement value of each milestone in the most popular language course. In Duolingo, each course is considered as a particular learning environment. Therefore, our studies aim at analyzing the effect of a winning streak by using the most popular language course as our testbed. Although we should consider other language courses, the first result is enough to indicate that the use of a winning streak in Duolingo caused the same effects as in video games and sports games.

According to the difference of GR values between two kinds of users, the results show that the streaking-users are more attracted rather than the normal-users. Additionally, by comparing the increase ratios of attractiveness and the streaking-users percentages between milestones, the results also expressed that a winning streak is more significant for advanced users rather than beginners. In conclusion, a winning streak helps to increase users' attention to their learning purpose when the challenges increase. It also works well in improving motivation of users because of its attractiveness. When a winning streak reaches an appreciable length, it becomes more precious. Users do not want to lose their winning streak because they have to pay many efforts to reach that length. Therefore, users have to keep their learning process go ahead every day for winning streak lengthening. That leads to a winning streak increases its attractiveness as it lengthens

Our future works focus on the application of the game refinement theory in various types of educational games. We will not only aim at analyzing the effects of game-based elements in an educational environment, but also try to examine the advantages of using game refinement theory as an assessment method by comparing it with other methods. Moreover, analyzing several popular educational games will help us find the appreciate range of enjoyment in the serious game domain. This range is a foundation for finding the most comfortable settings of game-based elements.

## REFERENCES

- Barata, G., Gama, S., Jorge, J., & Gonçalves, D. 2013. Engaging Engineering Students with Gamification. *In Games and Virtual Worlds for Serious Applications (VS-GAMES), 2013 5th International Conference*, 1-8.
- Camerer, C. F. 1989. Does the Basketball Market Believe in the 'Hot Hand'? *The American Economic Review*, 79(5):1257-1261.



- Carvalho, M. B., Bellotti, F., Berta, R., De Gloria, A., Sedano, C. I., Hauge, J. B., Hu, J. & Rauterberg, M. 2015. An Activity Theory-Based Model for Serious Games Analysis and Conceptual Design. *Computers & education*, 87, 166-181.
- Deterding, S., Dixon, D., Khaled, R., & Nacke, L. 2011. From Game Design Elements to Gamefulness: Defining Gamification. *The 15<sup>th</sup> international academic MindTrek conference: Envisioning future media environments*, 9-15.
- DOTA2 Hero Kills. [http://wiki.teamliquid.net/dota2/Gold#Hero\\_Kills](http://wiki.teamliquid.net/dota2/Gold#Hero_Kills) [20 March, 2017].
- Duolingo. <https://en.wikipedia.org/wiki/Duolingo> [20 March, 2017].
- Gunter, G. A., Kenny, R. F., & Vick, E. H. 2008. Taking Educational Games Seriously: Using the RETAIN Model to Design Endogenous Fantasy into Standalone Educational Games. *Educational Technology Research and Development*, 56(5-6): 511-537.
- Hamari, J., Koivisto, J., & Sarsa, H. 2014. Does gamification work? - A Literature Review of Empirical Studies on Gamification. *In System Sciences (HICSS), 2014 47<sup>th</sup> Hawaii International Conference*, 3025-3034.
- Huynh, D., Zuo, L., & Iida, H. 2016. Analyzing Gamification of “Duolingo” with Focus on Its Course Structure. *Games and Learning Alliance*, 268-277.
- Jeurig, J., Van Rooij, R., & Pronost, N. 2013. The 5/10 Method: A Method for Designing Educational Games. *Games and Learning Alliance*, 364-369.
- Klopfer, E. 2008. *Augmented Learning: Research and Design of Mobile Educational Games*. MIT press.
- Nossal, N., & Iida, H. 2014. Game Refinement Theory and Its Application to Score Limit Games. *In Games Media Entertainment (GEM), 2014 IEEE*, 1-3.
- Scepanovic, S., Zaric, N., & Matijevic, T. 2015. Gamification in Higher Education Learning-State of The Art Challenges and Opportunities. *In Proceedings of the Sixth International Conference on e-Learning*, Belgrade.
- Shaffer, D. W. 2006. *How Computer Games Help Children Learn*. Macmillan.
- Sutiono, A. P., Purwarianti, A., & Iida, H. 2014. A Mathematical Model of Game Refinement. *In International Conference on Intelligent Technologies for Interactive Entertainment*, 148-151.
- Takeuchi, J., Ramadan, R., & Iida, H. 2014. Game Refinement Theory and Its Application To Volleyball. Research Report 2014-GI-31, Information Processing Society of Japan, 1-6.
- Winning streak. [https://en.wikipedia.org/wiki/Winning\\_streak\\_\(sports\)](https://en.wikipedia.org/wiki/Winning_streak_(sports)) [20 March, 2017].

Duy Huynh  
 Hiroyuki Iida  
 School of Information Science  
 Japan Advanced Institute of Science and Technology  
 1-1 Asahidai, Nomi, Ishikawa, Japan 923-1211  
 duyhuynh@jaist.ac.jp, iida@jaist.ac.jp

Received: 31 May 2017  
 Accepted: 30 November 2017