Reward-based Intermittent Reinforcement in Gamification for E-learning

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Abstract: Nowadays gamification is a hot topic in the world, a lot of websites, applications and researches adapt this method to arouse users' motivation. From the past experience, gamification indeed has a positive influence on users' motivation especially in e-learning field. However, the gamification method either is hard to be applied to professional content called meaningful gamification or is negative on user's intrinsic motivation called reward-based gamification. So we study the game addiction mechanism and propose the reward-based intermittent reinforcement method in gamification to take advantage of user independence feature in the latter one and eliminate the negative influence on user's intrinsic motivation. In order to investigate the practicability and integrate effectiveness, we implement this model in our tele-teaching platform.

1 INTRODUCTION

Gamification is growing rapidly and becomes a important tool in various areas since it appears in 2010. In last four years, it has been applied to a lot of scenes like education, work and so on. Researchers and engineers utilize its advantages to sustain the existing users and attract the new. Figure 1 shows the search result from Google scholar search engine.

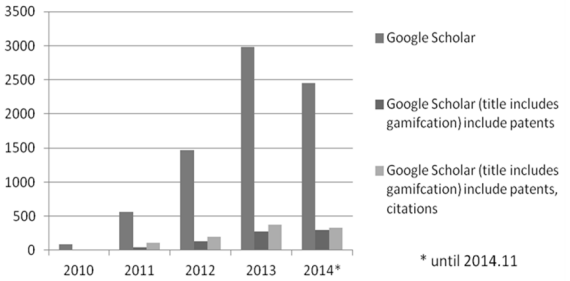

Figure 1: Searching result of gamification.

As showed in figure 1, the number of researches about gamification is increaing rapidly. In 2010, there is only one search result which includes "gamification" in its title. However, this number is as high as 1090 only after 4 years. This rapid growth shows that more and more researchers begin to utilize gamification in their works.

Additionally, gamification is not just research and theory, it also has been integrated into a lot of platforms, especially the e-learning platform. For example, "Codecademy" (e.g Learn to code, 2015) is a website to learn programming. It takes full advantage of gamification to make learning code funny and provide a new learning experience for learning code. Moreover, Hamari et al. (2014) prove the positive effect of gamification from lots of researches about gamification, it is that gamification can bring higher engagement and enjoyment in various contexts. In gerneral, past experience proves the advantages of gamification for e-learning.

Our research is based on our e-learning platform "tele-TASK". tele-Task (Schillings and Meinel, 2002) is an integration solution for recording lectures and presentations, post-processing and publishing them on the internet as shown in Figure 2 (Tele-TASK: More than video!, 2015). It contains several parts which are recording, live streaming and archive. In archive part, portal, iTunes U and mobile website are used for publishing our lectures. The target of tele-TASK is recording lectures, seminars, conferences or any professional videos. Users are mainly doing self-learning and after-class learning in our context. They belong to individual learning which is different from MOOC that has time-limitation or many users are learning in the same time. So they have higher requirement for users' motivation, engagement and conscientiousness. In

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addition, that the content of our platform are professional or theory courses means higher difficulty and less enjoyment. Consequently, users in our platform are more easier to be disturbed and the dropout rate is higher.

Figure 2: Tele-task workflow.

Our research mainly aims at utilizing the advantage of gamification to increase users' motivation, engagement and the enjoyment of learning in our tele-TASK learning platform. The main research question related to our target are: (1) What is the state of the art gamification method? (2) What are disadvantages and advantages of those methods? (3) Which method is most suitble for our platform? (4) How to optimize this method for a better outcome?

The rest of this paper is organized as follows. Section 2 gives a brief introduction of existing gamification researches concerning on learning and the theory foundation of our research. In section 3, we explain the implementation of common reward gamification in our portal. Section 4 discusses the model of reward-based intermittent reinforcement in gamification. Conclusion and future plan can be found in Section 5.

2 RELATED WORK AND THEORY FOUNDATION

Utilizing game in learning contexts has a long history. In the first place, researchers used the method of designing a game to design a learning course. This method is game-based learning (Prensky, 2003). After that, Shih, Squire et al. (2010) analyze the research trends of the information and communication technologies for game-based learning. Lau et al. (2014) discuss the research challenges and future trends of latest e-learning specific multimedia technologies, and one of those potential research directions is gamification.

Figure 3 shows that game-based learning and gamification, they both are methods to combine

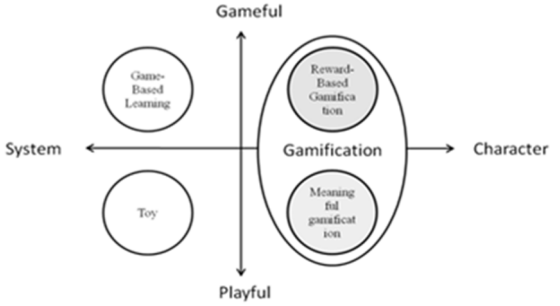

Figure 3: Relationship between game-based learning, gamification, reward-based gamification and meaningful gamification.

game with learning. Gamification consists of reward-based and meaningful gamification. Here system and character mean the whole game system and character of game system, respectively. It is obvious that the difference between game-based learning and gamification is the utilization percentage of game. Game-based learning is a game with learning contents, while gamification is learning course with game elements.

In Figure 3, gameful means rules and competition or strife or goals. Playful means improvisation, expressiveness, spontaneity, and joy (Lucero et al., 2014). Here meaningful gamification is one typical kind of playful gamification design method. Reward-based gamification is utilizing the game rules and relying on the extrinsic rewards, while meaningful gamification is utilizing the joy of game and relying on intrinsic rewards. So gameful and playful are the main difference between those.

The definition of these methods can be find in (Prensky, 2001), (Deterding et al., 2011) and (MIT Game Lab, 2013). From these definitions, it is obvious that game-based learning is not suitable to be applied in our context. Therefore the remaining potential methods are reward-based gamification and meaningful gamification.

Meaningful gamification is first proposed by Prof. Scott Nicholson in (Nicholson, 2012). After that, he applies it to classroom management (Nicholson, 2013) and proposes six concepts about meaningful gamification (Nicholson, 2015). Beside meaningful gamification, some other researchers propose to use playful design in gamification like (Deterding et al., 2011) (Lucero et al., 2014). Based on this meaningful or playful design, intrinsic motivation which is very helpful for learning can be aroused. However, it only has been applied to primary courses or activities but no professional courses. Higher difficulty and less playful in professional course are the main reasons. That is to

say, this meaningful design or playful design is not applicable too.

The remaining gamification method is reward-based gamification which is the mainstream in gamification researches. Hakulinen et al. (2013) prove that achievement badges can be used to affect the behaviour of students even when the badges have no impact on the grading. Iosup and Epema (2013) prove that gamified courses show a high ratio of students who pass after the first attempts. In the summary made by Hamari et al. (2014), reward-based gamification in education are positive. Especially, one online learning platform has been reviewed in (Hamari et al., 2014), and the result shows that reward-based gamification has a positive impact on time management, carefulness and achieving learning goals.

However some researchers argue that reward-based gamification is not a suitable method because extrinsic reward has negative influence on the intrinsic motivation (Deci et al., 2001). Those who perform some activities because of rewards will be less motivated when the reward is moved. So the long term things like behaviour change and learning should adapt other method to call forth the intrinsic motivation.

In summary, reward-based gamification is suitable for our context, it can help to arouse users' motivation, but it also has negative influence on long-term learning activities. So in our research, we focus on adapting the advantages of reward-based gamification and proposing a new method in reward-based gamification for sustaining the motivation and engagement of long-term users. In the first place, we import the common badge system into our platform, that is a general thing which you can find in lots of gamified websites. The next is our reward-based intermittent reinforcement model in gamification. The goal of this model is keeping long-term users' motivation and engagement. The theory basic comes from game addiction theory.

Game is easy to attract users' motivation and engagement because it is a game. But not all games can be played for a long time, some games are specially attracted, some aren't. In game design, lots of factors affect the quality of a game, like graph, music, story, additive mechanism and so on. There is no standard for every factor, but user must get some positive stimulations from the good element.

The elements in game design can be divided into two kinds, one is user-related; the other is user-independent. Elements like reward, badge, leader board are independent of user. Elements like story, music are related to user. Because everybody has his own idea even for one thing, it is impossible to design a element which everyone likes. Because of independence, the positive stimulation of user-independent element is more direct and it can attract more users than user-related elements do. Game addiction mechanism which is also user-independent element is the rule of positive stimulation occurring. A good game addiction mechanism can amplifier the effect of positive stimulations. Then player will be attracted by this game which also turns into a good game. So a good game must be a addictive game. (Flappy Bird, 2014) is good example about addictive game. It only has a good addiction mechanism, beside the addiction mechanism, nothing in this game can be thought as a good design.

Prof. Bennett Foddy from Oxford explained the main addiction mechanisms in game design. The first is immediately feedback that a gaming experience is more addictive if it has shorter latency between reward and action (Ethics and Addiction in Games – Develop Conference, 2012). The second is intermittent reinforcement. The third addiction mechanism is the diminishing reward which means improve the difficulty of getting a reward step by step.

The first addiction mechanism actually is used in lots of gamified websites and our platform. That is the common reward method in common badge system. Simple award rules bring shot latency, so it can help to arouse users' motivation. But it has negative influence on users' intrinsic motivation.

The second and third addiction mechanism are applied in our platform by a intermittent reinforcement based on diminishing reward. We improve the initial difficulty of getting next badge, but whether the user can get a badge is completely random. There is a experiment about intermittent reinforcement. Rats are given a button that provides food on different schedules – every time it's pressed, every tenth time, or randomly. The result is that the rat is far more likely to compulsively hit the button if it's on a random schedule. The intermittent reinforcement can be found in the slot machines, that why it has been popular for so many years. From the psychology experiment (Cameron and Pierce, 1994) (Hogarth and Villeval, 2010), intermittent reinforcement not only can lead to more persistence and higher total effort but also won't have any negative influence on users' intrinsic motivation. In addition, the random intermittent reinforcement also won't make users addicted.

In summary, the common badge system can rapidly arouse uses' motivation in the beginning, after that, the intermittent reinforcement takes

responsibility for sustaining users' long-term motivation and intrinsic motivation.

3 COMMON REWARD MODEL IN TELE-TASK

Figure 4 shows the homepage of tele-TASK portal which includes more than 5300 e-lectures, 19000 podcasts, 1900 lecturers and 420 collections (Bauer, 2015). It is the main video publishing window of tele-TASK. The biggest ratio of users are those who learn our courses after class or by themselves. And most of these videos are our professional courses and research seminars. Therefore, how to improve the engagement of users in our platform is our research key point.

Figure 4: Homepage of tele-TASK portal.

In order to improve the learning efficiency, we provide several learning tools for our users. Figure 5 shows the main tools in our portal. Those are tagging, marker, note (manuscript), rating and link. Besides, we have playlist and group tools for collaborative learning. The detailed function of those tools can be found in (Moritz et al., 2010) (Siebert et al., 2010).

In our model, the activities that users use tagging, maker, manuscript, rating, link, playlist are considered as effective learning activities. Our model monitors these activities to award users badges for arousing their motivation and keeping their engagement. So the effective learning activity is the foundation of our reword model. The approach in our system is awarding users based on the number of effective learning activities. For example, the model awards a level-0 tagging badge to user who tags 10 taggings, a level-1 tagging badge to user who tags 100 taggings.

The reason why we first import the common reward model into our system is its simple rule. Therefore reward is easy to be found by users thus

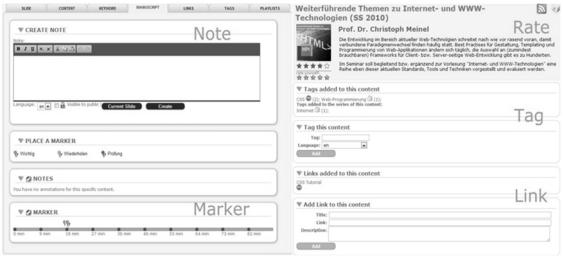

Figure 5: Learning tools in tele-TASK portal.

Figure 6: Main achievement page.

inspire users at first. In game addiction mechanism, the common reward model is the immediately feedback, which is the easiest way to arouse users' motivation and engagements.

Figure 6 shows the main achievements page of user. This page shows all badges obtained by one user in time order. There are several filters above all badges, those are used for showing the badges in one certain aspect.

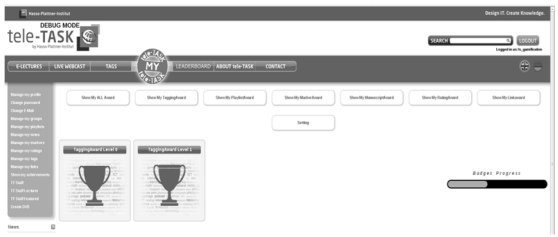

Figure 7: Badges in one aspect.

Figure 7 shows the certain badge page which contains all badges from low level to high level in one certain aspect and its current progress. The progress function gives the user a clear brief of their badge status. So it is a good assistance for our intermittent reinforcement reward which is a random mechanism. Because of the random feature, users can't know that if there is no hint. But the progress

bar provides a good hint for intermittent reinforcement reward. Once they know this badge, the intermittent reinforcement reward just like a slot machine in our portal.

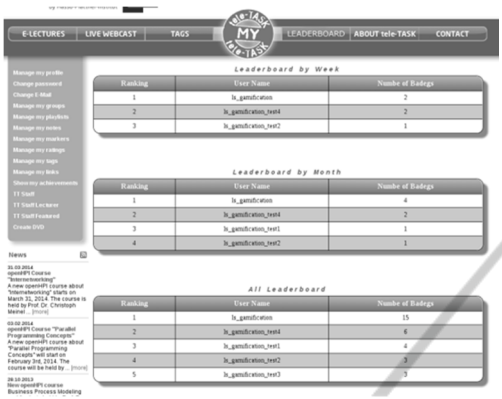

Figure 8: Leader board.

Figure 8 shows the leader board in our badges system, the leader board has different time slots. There are three different time slots which are last 7 days, last 1 month and whole time respectively. New user can easily enter the leader board based on short time slot. Therefore, shot-term leader board is designed for arousing the motivation and engagement of the new user. The leader board of whole time is based on the all badges in our system, so it won't change so quick and is used for sustaining the motivation of old user.

These above methods are designed for users who like badges or like to compare with others, but not all users like that, especially, some users don't like, and even worse, hate this comparison. Actually, we conduct a survey which contains a question about gamification, more than 20% users aren't interested in gamification or dislike gamification. So in our design, we also consider the requirement from this part of users, no matter badges or leader board, users have the right to turn it off if they want. But the turn-off function of leader board is only valid for the user who is already log-in. Regarding visiting user, they have no right to turn it off.

The section above is the common method in our system. Lots of websites have this common reward system which may have different patterns of manifestation. But the theoretical foundation, that is just like that we use candy to persuade children to try some new things, is same. The goal of common method is arousing users' motivation at first sight. When people have no idea about content, reward is the most direct positive stimulation for them, so they will be attracted by badges. But this common method just has a good effect on new user, because it uses a very simple calculation method to award users. That is "You do it , I award you". Therefore once users know this rule, it will be less attractive than at the beginning, and then reward can't arouse users' motivation and engagement anymore. It is necessary to propose another method for sustaining our users' motivation for a long time. The next part will explain this solution in detail.

4 REWARD-BASED INTERMITTENT REINFORCEMENT MODEL

In this chapter we will explain our method to sustain long-term users' motivation. As we explain in chapter 3, addiction mechanism is a very important to the quality of game. It decides the effectiveness of positive stimulation in game. Here we adapt the intermittent reinforcement and diminishing reward to keep users' motivation. The implementation detail is described as follows:

- Model monitors all effective learning activities.
- Model calculates the probability of gaining points after find a effective learning activity. Three variables that we will explain later contribute to the probability result.
- A random number is generated by model for comparing with the probability result. Comparison result decides whether to add user's random badge point.
- If user's point increases, then the failure times will be cleared. Progress will increase and our model will check the point whether it meets the requirement of next level. If comparison result is negative, the failure times will increase by 1.
- Every new level badge is awarded, the badge number will increase, which has an effect on the basic probability.

This probability is calculated by the opportunity calculation function which is showed in function (1):

$$f = 0.3\left(\frac{6}{x^2+6}\right) + 0.4\left(\frac{y}{y+15}\right) + 0.3(1-z)^2 \quad (1)$$

$$x \in [0,4]\ \ y \in [0,\infty)\ z \in [0,1) \quad (2)$$

Here X means the number of badges which user owns, Y means the failure times, Z means the progress to next badge. (2) shows the domain of these three variables. So the range of F is from 0 to 1.

The domain of sub-functions can be found in the next.

$$\begin{aligned} \mathrm{f1} &= 0.3\left(\frac{6}{x^2+6}\right) \\ &\in [0.3, 0.257, 0.18, 0.12, 0.099] \end{aligned} \tag{3}$$

Function (3) is the first sub-function of our calculation method. Now we only have five levels for this badge, so the number of X can only be 0,1,2,3,4. Then the basic probabilities of this sub-function are 0.3, 0.257, 0.18, 0.12, 0.099. It is obvious that the success probability is decreasing with the increasing of badge number. That is to say, the difficult of gaining another badge is directly proportional to badge level.

Figure 9 shows the probability curve of function (4) which is based on failure times (y). It is obvious that this function is a increasing function and the maximum of the function is 0.4. When design this function, we want it increase slowly in the beginning, while it increases faster and faster with the increasing of failure times. This design can bring a suitable degree of difficulty.

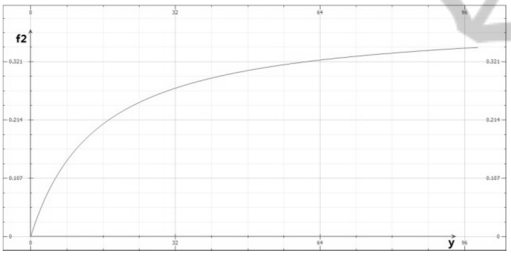

Figure 9: Probability curve of failure times.

$$f2 = 0.4\left(\frac{y}{y+15}\right) \in [0, 0.4) \tag{4}$$

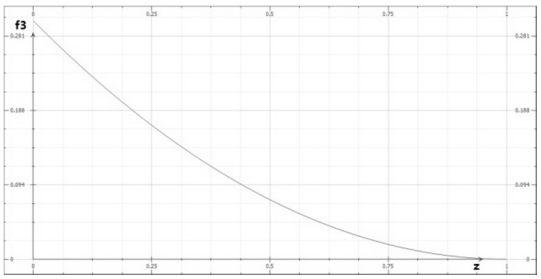

Figure 10: Probability curve of progress.

$$f3 = 0.3(1-z)^2 \in [0.3, 0) \tag{5}$$

Figure 10 is the probability curve of progress as shown in function (5). Here Z means the progress to next badge. This design also adapts diminishing reward concept, it can bring a good influence on users' motivation.

In function (1), when x equals 0, function (1) equals function (6).

$$\mathrm{f} = 0.3 + 0.4\left(\frac{\mathrm{y}}{\mathrm{y}+15}\right) + 0.3(1-\mathrm{z})^2 \tag{6}$$

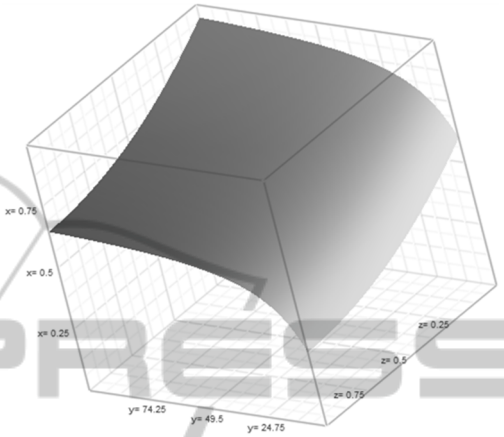

Figure 11: Probability plate when badge number equals 0.

Then the function (6) is shown in Figure 11. In this figure, X, Y, Z individually stands for the probability F, failure times and progress. Figure 11 gives a direct explanation of how failure times and progress affect the probability. In addition, when failure times is 0 and progress is close to 1, the probability is 0.3. While the progress is close to 0 and failure times is 100, the probability is 0.9478260869565.

$$\begin{aligned} \mathrm{P} = \sum_{\mathrm{i}=0}^{\infty} \{ [\, & 0.3\left(\frac{6}{a^2+6}\right) + 0.4\left(\frac{i}{i+15}\right) \\ & + 0.3(1-b)^2] \prod_{\mathrm{j}=0}^{\mathrm{i}-1} [1 \\ & - 0.3\left(\frac{6}{a^2+6}\right) \\ & - 0.4\left(\frac{j}{j+15}\right) \\ & - 0.3(1-b)^2] \} \end{aligned} \tag{7}$$

$$P = \sum_{i=0}^{\infty} \left(\frac{i+9}{i+15} * \frac{6^i * 14!}{(i+14)!}\right) \tag{8}$$

We assume that the badge number is "a", progress is "b". The total probability of awarding user points is function (7). When a new user uses our system, then both "a" and "b" are 0, so the probability of gaining the first point can be

calculated by function (8). The result of function (8) is close to 1.

In our model, high level of badge means more points. Currently the required points for 5-level badges are 100, 300, 800, 1900, 4200. The required point to the next level is double of the required point of existing level plus the next level multiplies 100. Our model rises the difficulty with the rising of badge numbers, and the progress is also based on the difficulty rising model. The failure times in this model is used for ensuring that user can gain the badge at last after many tries. In one word, It is harder and harder to get more badges, but it becomes easier and easier with the rising of failure times. That difficulty is related to user's level is diminishing reward theory. While random number is the one who makes a decision about if user can gain the point. Fundamentally, it is intermittent reinforcement. These two mechanisms work together to arouse users' motivation and sustain users' long-term motivation.

5 CONCLUSIONS AND FUTURE WORK

In this paper, we propose a reward-based intermittent reinforcement model in gamification for e-learning. It consists of common reward model and intermittent reinforcement model. The former utilizes the number of effective learning activities to award users. The latter one is based on the probability calculated by user existing status. In our model, these two models not only can arouse users' motivation at the first place but also have a good persistence for long-term learning. In addition, it is easy to implement and has no concern to users' background, experience and so on. In one word, this model overcomes the shortcomings of reward-based gamification and meaningful gamification, it is particularly suitable for on-line learning platform with professional contents.

The basic framework of reward-based intermittent reinforcement model has been implemented. But there are still a lot of improvements need to be done in the future.

First of all, learning activity verify system is needed to ensure the effectiveness of learning activities. When evaluating our model, we find that our learning activity system has a potential risk which is the cheating from user. Our model calculates every learning activity without verification, if a user malicious chases a badge, invalid operations will appear but still be counted into model. For example, one will use the same text for lots of notes or same tagging for lots of videos. Therefore, we intend to use the operation time of activity to verify the effectiveness of activity. That the duration between two activities is too short means user must be cheating now. But different activity should have different time slot. If there is tagging on the video page, the tagging event is a easy action which is only a click. The marker event also occurs very close at a big probability. So the time slots of these should be as small as that people can do it twice in the best internet condition. While the "Note" "URL" "Playlist" should cost a long period of time, because user needs to type something, interactive with database or click several buttons, so the time slot can't be too narrow. Too big time slot for "Tagging" and "Marker" and too narrow time slot for "Link" "Playlist" "Note" are invalid, because the former one will ignore the valid learning activities, the latter will bring misrecognition of invalid one.

Furthermore, using evaluation to bring a better reinforcement result. The common reward method of gamification is obvious effective for e-learning. But the effectiveness of reward-based intermittent reinforcement model and the parameters of this model need long-term experiment to verify and optimize. Unfortunately, there is no accuracy mathematic model for the difficulty model in game addiction theory. All difficulty model come from the psychology experiment or experience which are not precision, although our model is based on the theory of game addiction mechanism, it doesn't mean that our model is optimized in e-learning. So lots of experiments are need for optimizing parameters, making the system suitable for more users.

We intend to evaluate our method in our real course. Two platforms will be provided to our students in the same time. One is original portal without gamification module, the other is testing portal with gamification module. Every student needs log in our platform with his own account. After the end of this class, the effectiveness of gamification can be verified by comparing the number of users, the online learning duration, the final score in these two platforms. Moreover, we can get more information by designing a survey for our platforms. Especially, the result from the users who pay less attention on our platform can help us a lot to improve the universality of our gamification method. The parameters of our reward-based intermittent reinforcement model can be evaluated in the same way which is comparing the result from platform

with reinforcement model and without reinforcement model in real course. Once or twice evaluation experiment can bring optimized parameters for our platform.

At last but not least, extending the system for the users who are not interested in gamification or reward. There are three kinds of users whom our existing model can't motivate. They are users who have a clear learning target, have no interests in our reward or in gamification. The first kind of users don't need any extrinsic motivation to arouse their motivation, they have enough intrinsic motivation. While the second kind of users need us provide more kinds of reward to inspire them. We have the close option for the third kind of users, but that is not enough. We can try to express our content or platform with more creative and interesting way or build some playful learning assistance tool to attract these users.

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