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AN AWARD SYSTEM FOR GAMIFICATION IN HIGHER EDUCATION

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Abstract

Higher Education Institutions (HEI) have the missions of education, at a high level, research and cooperation. Regarding education, HEI must create an appropriate environment for learning, towards high-level academic performance. The conciliation of education and research paves the way for an adequate learning environment, further reinforced by the students' motivation. Motivation depends on several factors, some of them external, such as earning money, gaining social status, have a higher grade, and/or internal (intrinsic), which results from the person's core self (associated to the satisfaction people feel when doing something appealing).

This paper describes the approach to applying gamification to a higher education subject in the course of computer science. It uses several game design mechanisms, such as adaptive challenges, rewards, curiosity and chance to increase the time students spend working, experiencing and learning in a HEI. The sections in the subject's curriculum are transformed into levels, awarding stars for increasingly complex achievements. Grades depend on the learning experiences students' choose, as well as on the time spent solving the challenges presented to them. There is also the concept of soft currency, which we call BitPoints, that can be used to increase the student autonomy and reduce the workload.

An online platform is constantly available to inform the student about his or her progress within the subject as well as the grade at the moment of the access. Each level is represented by a castle on a map, which is considered conquered as soon as the student solves the required challenges. Depending on the difficulty of the challenges faced, the student can face a lower grade or a higher grade. Only after finishing all the levels, the student is able to successfully finish the subject.

Virtual money can be spent in a virtual shop, where the student can invest in tools that can help solving some tasks. The virtual shop provides scripts, instructions and other techniques that can be valuable to students. A chance factor is also considered in the shop, giving further motivation to students.

In the preliminary assessment of the process, students demonstrate willingness to compete not only to pursue the highest grade but also on the amount of collected BitPoints and on the speed to complete a level. Moreover, students frequently come back to previous levels and learning experiences, to further

test the acquired skills.

Keywords

Author Keywords: Gamification; Higher Education; Educational Games; Award System

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Abstract

Higher Education Institutions (HEI) have the missions of education, at a high level, research and cooperation. Regarding education, HEI must create an appropriate environment for learning, towards high-level academic performance. The conciliation of education and research paves the way for an adequate learning environment, further reinforced by the students' motivation. Motivation depends on several factors, some of them external, such as earning money, gaining social status, have a higher grade, and/or internal (intrinsic), which results from the person's core self (associated to the satisfaction people feel when doing something appealing).

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Keywords: Gamification; Higher Education; Educational Games; Award System.

1 INTRODUCTION

Higher Education Institutions (HEI) have three primary missions: education, research and cooperation [1]. While in different weights and strategic importance, most institutions try to cope with these missions to contribute for population education at high level, scientific and technological advances and economic and social development.

Regarding education, HEI must create an appropriate environment for learning. However, adequate student learning disposition is fundamental to achieve high-level academic performance [2]. The way they plan, monitor and modify their learning, how they manage and control their effort on academic tasks and the cognitive strategies used to learn, remember, and understand materials all contribute to the overall education process within the student.

Students must be motivated to use the strategies as well as regulate their cognition and effort [3]. A motivated student is energized and available to pursue activities and tasks that appeal to him. Delivering content alone has virtually no effect on students' beliefs about the world. They can memorize data, but without active engagement and hands-on application, they do not really confront the implications of the new content.

There are several factors that determine motivation, and usually they also depend on the person characteristics. To foster motivation it is important that students understand what they can and can't do and have accurate and realistic feedback that can help them acquire the expertise needed to learn. It is also fundamental to provide tasks that should be neither too easy nor too difficult, but challenge students in appropriate ways [4]. High-degree of motivation is usually achieved when the expectations are high [5]. Low stakes and high expectations are precisely the typical conditions of a good game.

With this in mind, we designed a higher education subject, of the computer science course, around game concepts and mechanics. This gamification approach allowed us to define adaptive challenges, a reward system, curiosity and chance to increase the time students spend working, experiencing and learning in a HEI. The sections in the subject curriculum were transformed into levels, awarding stars for increasingly complex achievements. There is also the concept of soft currency, which is used to increase the student autonomy and incentive the workload. Some games are also used as learning experiences, allowing collective knowledge building in the preparation and also playing the games.

This paper describes the adaptation and design of an award system to both motivate and grade students. The approach provides a self-regulated assessment system, giving the student immediate and constant access to the learning process, maintaining, at all times, awareness about what he has learned and what he still needs to learn. Moreover, he also has a quantitative and qualitative notion of the final grade, allowing him to make options regarding the final grade.

This paper is structured in five sections, starting with this introduction. The next section describes related work as well the overall gamification approach. It proceeds by describing the design and evaluation of the award system and we finish with some conclusions.

2 RELATED WORK

Playing games is something that has been with humans since the dawn of civilization. Recent research has been demonstrating that game play contributes to faster reactions as well as to increasing the brain activity, allowing people to live longer and delaying dementia.

In the context of education it has been more common to use games, either custom designed or off-the-shelf commercial, to foster learning. These have been used in specific themes under the syllabus, such as learning or relating concepts or extrapolate through simulation.

The use of games for learning in higher education aims to make complex theoretical knowledge more accessible, providing the means for students to repeat and simulate situations that may lead to a more in-depth learning. Based on the possibility of fantasy, challenge and curiosity that characterizes games, the online game Internal Force Master (IFM) is an educational game software specifically designed and developed for the study of Civil Engineering [6]. It was developed in Macromedia Flash and made available to master level students. The authors concluded that the learning result of the playing group is at least equivalent to the group who learned using the traditional method. Moreover, they also state that gambling can be a new, modern and also useful learning method.

Effective learning and learner autonomy promotion is a recommended by several governments and education institutions. In this context, learning by doing is instantiated in the development of games by the students, allowing them to acquire a diverse set of skills. The Adventure Author used this approach, showing that game making provides a range of opportunities for successful learning [7]. Children were motivated and enthusiastic, showing determination to achieve and ability to learn collaboratively and alone. They also showed evidence of being able to link and apply their learning to new situations. Off the shelf, commercial games can also provide valuable learning experiences for students. The choice and evaluation of games allows better adaptation of requirements and learning goals [8], [9].

On the other hand, specific, custom developed games, can provide a uniform and specific learning environment. Digital forensics, for example, is complex and requires a diverse set of skills through expensive specialized tools. Digital Forensics Interactive is developed in Unity to build a virtual environment to students. The game-play consists of the challenges and actions the game offers players and the sequence of the game is the progression of activities that consists of the game [10].

The inherent complexity of such games requires large efforts for their development. Specific frameworks can be followed to maintain the process within controlled complexity without losing sight of the main goals, either in game-play and on learning goals [11], [12]. However, designing a whole higher education subject around gamification is not frequently found.

2.1 Gamification in Higher Education

This paper describes a work part of a large experience of completely design a higher education subject using game concepts and mechanics, maintaining the learning goals and curricular structure. Overall, we intend to increase the time and attention students dedicate to learning. The path to achieving this is through motivation, which psychology divides in two groups: intrinsic and extrinsic motivation. The former derive from our core self and the latter depends, or is driven by, the environment that surround us, such as the desire to earn money or to gain social status or prestige.

Most humans, as well as other organisms, are motivated by the development of competences in dealing with the surrounding environment. This explains their exploratory nature, towards acquiring and pleasurelessly using recent acquired skills. Skills are further improved, and satisfaction follows, through permanent challenging activities, adjusted by the difficulty level. This implies the existence of clear criteria for performance, through a concrete feedback mechanism, allowing the person to assess how well or how poorly he is doing at any time. In other words, different degrees of challenges are necessary, with adequate feedback and performance measurements, so that the person will be able to obtain increasingly detailed information about his skills and competences. Feedback should be presented to participants regarding how closely their current level of performance matches their goals, with the intention to guide them to excellent performance [13].

Curiosity also plays an important motivational role. In fact, it represents one of the most important factors, since it drives the actor to permanently keep investigating and experimenting until he is satisfied. Curiosity can even drive people to engage activities that represent some risk, just for the sake of knowledge or in pursuit of new experiences and sensations.

An intrinsically motivating activity is engaging by itself, for its own sake, dismissing external rewards, such as money, status or grades. As described above, the key factors for an intrinsically motivating activity include challenge, fantasy and curiosity [14].

As mentioned above, constant, up-to-date feedback concerning the student performance is fundamental in this process. This provides a self-regulated assessment system, giving the student immediate and constant access to the learning process, maintaining, at all times, awareness about what he has learned and what he still needs to learn. It also allows the student to make choices related to the learning process, including the difficulty level, the challenges and others.

The implicit notion of a game implies that there is a specific objective, a goal to pursue. The goal has to be meaningful and adequate, requiring the increasing ability to challenge the player, not getting boringly simple. It also requires increasing skilled performance to overcome phases and obstacles. Usually, they also have fantasy elements, such as piloting a plane, ruling a city, becoming an emperor, and others. The game should also have a performance metric system, based on the time or on the scores the player achieve. The challenge is also dependent on an uncertain outcome, either by a variable difficulty level, by existing hidden information or by randomness.

Multi-goal approaches also contribute to adapt the challenge to the skills of the person. For example, the challenge to finish a level is different than finishing it holding all the collectibles or even finishing the game. These multi-goal structures are associated to the reward system, allowing the game to maintain the track of the player skill and performance metrics. This constitutes the games' challenge-achievement-reward loop, which has the effect of reinforcing the desire to play [15].

2.2 Orthogonal motivation in games

Games adopt complementary mechanisms to increase challenge, known as “achievements”. These consist of optional challenges, independent of the main game session, yielding possible rewards [16]. It is possible to play and succeed in completing the goals of a game without pursuing achievements. However, the possibility to be surprised by a meaningful element, such as a tool, a clue, a badge or other contributes to curiosity and to increase the inherent challenge of the game.

When used outside individual games, this mechanism defines another game in itself, equivalent to quests, allowing the definition of players' profile as well as types: achievement casuals, hunters and completists.

2.3 Game Mechanics

The act of playing a game assumes that there is a set of functional components, with the ability to guide the player actions. This set of tools is known as game mechanics and they provide the fundamental bricks of game design. There are six primary elements, which can be combined according to specific game design patters: points, levels, leaderboards, badges, challenges, and onboarding [15].

2.3.1 Points

Points are intrinsically associated with games. In sports, for example, earning more points than the adversary is, in fact, the goal of the game. Other games also use points as the result of fulfilling some task or bonus activity. Points are designed according to the situation and effect they intend to provide, whether to measure the player's progress, to be used as currency to buy tools or objects, or simply to give away.

Tower defense games, such as Kingdom Rush, combines several of this points to complete the player experience. Redeemable points (soft currency) are earned, as enemies are defeated, allowing him to build more towers or to upgrade the existing towers. Experience points are translated into the number of starts the player receives, which depend on the number of completed levels as well as of the relative success in completing them (lives lost, for example).

2.3.2 Levels

Levels indicate progress, allowing the player to know where he is in the gaming experience over time. Each level usually maintain the same rules as the previous, introducing new tasks that are increasingly challenging or that demanding better skills to complete. This complexity transitions between levels are extremely engaging, allowing the player to gain experience and to, later on, get back to the previous levels and solve them according to a different strategy of set of skills.

2.3.3 Leaderboards

Leaderboards are used to provide feedback and relative performance metrics to the player. In other words, they provide a mechanism for simple comparisons. The use of this game mechanic is sensible and can, if not used correctly, disincentive the player. To prevent this, the leaderboard can show the player in the middle of a table, regardless of where he is in terms of score. Another approach is through infinite leadboards, preventing the user from “falling” off the table or from getting stuck in a position forever. By being a form of comparison, it may raise privacy issues, since it may reflect sensitive of private information.

2.3.4 Badges

Virtual rewards are collected by the player in a sense separated by the rest of the game [17]. They do not affect the game goals and how they are achieved, although they influence the whole experience [16]. Achievements are awarded with the completion of optional subgoals, usually requiring thorough exploration, new play styles, and virtuosity, becoming an efficient way of extending the lifetime of a game [18].

A reward system is complex and encompasses different concepts, such as the score, the collectibles and achievements. Game achievement systems translate the player investments into a more quantifiable, comparable and communicable form, allowing the players not only to monitor and plan their actions but also make them more aware of how their skills rank among their peers [19].

2.3.5 Challenges

As described above, the game has to provide challenges with an adequate degree of complexity and uncertain outcome. Levels and optional sob-goals can help maintaining adequate challenge level.

In the context of higher education, some of the mechanics are easy or can immediately be applied. Points, for example, can be used to foster autonomy through soft currency (redeemable points) or experience points, rewarding the complexity if the tasks the student is able of achieving. Levels provide a clear path or direction to the students and include the available challenges and subgoals. On the other hand, leaderboards could harm the motivation of average students. Badges are particularly useful to build the student profile. We chose not to implements this mechanism because it can also disincentive collaboration between students.

3 ASSESSMENT SYSTEM

Before the changes introduced, the subject was structured in four sections or chapters. Each section had several themes that should be mastered before advancing to the next section. The final assessment and the associated grade depend on the success on each of the section as well as the creativity and the level of knowledge demonstrated in every subject. Students are graded from 0 to 20, which is translated to the ECTS grading scale, demonstrating how she performed relative to other students (the best 10% are awarded an A-grade, the next 25% a B-grade, the following 30% a C-grade, the following 25% a D-grade and the final 10% an E-grade). Success is only considered if the student has a grade equal or above 10 (0-20).

After the introduction of game mechanics and concepts, the learning goals where maintained. The overall structure of four sections was also maintained, although adapted into levels. Each section corresponds to a level, with an additional fifth level, with the purpose of final integration of knowledge. The students have to overcome all the levels to succeed, granting him the 10 grade. Symbolically, each level is associated to a castle. Within each level, they can choose among three challenges with different difficulty degree: Easy, Normal and Hard. The difficulty is symbolic represented by stars – the higher the difficulty, the higher the number of stars. The challenges are instantiated in learning experiences, which can be games, traditional practical assignments or others.

Soft currency is introduced to foster the students' autonomy. Whenever an obstacle is overcome, the student collects BitPoints, the concept used to represent the soft currency. The more obstacles and the higher the difficulty, the more BitPoints collected. With this they can get access to additional tools and knowledge that they can use to solve other challenges. In summary, the reward system will have castles, stars and points (Table 1).

Table 1 – Reward system and structure.

Element	Description	Grade
Castle	Awarded for each completed level. Student will need five castles to succeed in the course.	Up to 10
Star	Each level will award up to 2 stars.	Up to 10
BitPoint	Awarded when completing a level. Can be used to buy tools or information.	-

The student can, at any time, see the evolution within the awards system using a standard web browser. This will present the completed levels, the levels still to come, the number of stars awarded in each level and the total BitPoints (Figure 1).

Figure 1 – The Level Map.

The level map also gives access to the item store, where the student can buy information or tools to be used in other tasks. The shopping list includes several items that can be valuable to overcome obstacles (Table 2).

Table 2 - Shopping list.

Price	Item
50	Command line string
250	Virtual machine file
350	Step-by-step configuration recipe
500	Configuration file
999	Service configured

The store provides information about all the five items, its price and the available BitPoints. It also provides the student with the number of items already bought (Figure 2).

Figure 2 - The Item Store.

Each time the student buys an item the teacher is notified. The total BitPoints are decreased by the corresponding amount and the number of items of this type is incremented. This number is initially greyed, meaning that the teacher has not delivered the item yet. Only after successfully delivering the item to the student this number will turn into white.

Each time the student selects an item, the description in the figure will change, to further explain the meaning of the item. If the number of BitPoints is enough to buy the item, the “Buy” indication will also appear, allowing the student to perform the transaction.

3.1 Levels

As described above, the student can progress advancing Levels and collecting Stars and BitPoints. The number, length and complexity of each level is associated to the content planned in each chapter. In other words, the level design is indexed to the associated chapter in the syllabus. However, to provide initial increased motivation, another level is added, in a total of five (Table 3).

Table 3 - Level list.

Level	Length	Description
1	1	Basic Concepts (Virtualization and OS)
2	2	Disconnected systems
3	1	Networked systems
4	1	Integrated network management
5	1	Wrap up and content integration

The length of each level determines the complexity and/or the number of learning experiences the student should perform in each one of them. This also determines the amount of time required in the process.

3.2 Stars

Stars are awarded according to the difficulty level the student was able to complete (Table 4). Several exercises and games are presented to the student, allowing him to choose according to the difficulty level (Easy, Normal, Hard).

Table 4 - Stars and challenge level.

Challenge	Description	Stars
Easy	The most simple exercises and games	0
Normal	More complex exercises and games	1
Hard	The most difficult exercises and games	2

The number of stars is awarded according to the difficulty of the learning experiences that the student fulfilled. Considering the maximum complexity (C_{max}) in each level as the sum of all the most difficult learning experiences, in which n is the length:

$$\{E = 0; N = 1; H = 2\} \wedge C_{max} = n \times H$$

The complexity succeeded by the student in each level (C_T), in which $\max(C_i)$ is the maximum difficulty in each step, is:

$$C_T = \sum_{i=1}^{n} \max(C_i)$$

Which translates into stars as:

$$Stars = \begin{cases} 0 & if\ C_T \leq 0.3 \cdot C_{max} \\ 1 & if\ 0.3 \cdot C_{max} < C_T \leq 0.7 \cdot C_{max} \\ 2 & if\ 0.7 \cdot C_{max} < C_T \end{cases}$$

For example, in a level of length 3, $C_{max} = 6$. The student completed one easy, one normal and one hard, giving $C_T = 3$. Since $\frac{3}{6} = 0.5$, the number of stars is 1.

3.3 BitPoints

BitPoints are awarded as each learning experience is completed. They can be used to "buy" tools and knowledge helping the student to overcome other challenges. In this context, the amount depends on the number and complexity of the learning experiences, the time necessary to complete them and the overall participation in and off classes. The complexity is directly indexed to a specific amount, as follows:

$$Difficulty = \begin{cases} Hard & 75 \\ Normal & 45 \\ Easy & 30 \end{cases}$$

Considering time, the sooner the student overcomes a challenge, the more it values. Considering x as the number of days to a predefined deadline:

$$BitPoints = Difficulty \cdot \left(\frac{3}{2} - \frac{e^{\frac{x}{2}}}{1 + e^{\frac{x}{2}}} \right) + Participation$$

This translates into rewarding the student to finish earlier, and affecting his earnings if delaying (Figure 3).

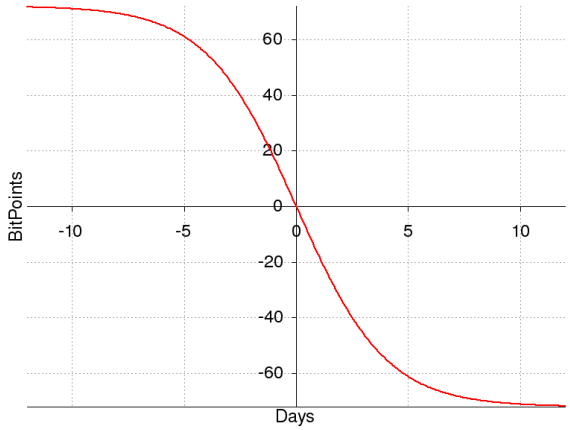

Figure 3 – BitPoints by moment of level completion.

The last share of the BitPoints sum is specific of the student participation and is of the responsibility of the teacher, up to a maximum of 50 BitPoints.

4 EVALUATION

The class had 24 enrolled students. Of these, 2 never showed, and 1 droped out after 1 week. In total, 21 students finished successfully the subject. A due date and a difficulty level characterized each learning experience. These would define the number of BitPoints earned after completion, according to the approach described above.

At the beginning of the semester, a total of 21 learning experiences where presented to the students, distributed as follows: 3 on the first level, 6 on the second level, 6 on the third level, 3 on the fourth level and 3 on the fifth level. The student would have to complete, at least, seven learning experiences to succeed in the subject. In average, the 21 students completed 8.1 learning experiences. Two students completed 10 and six completed 7.

The students started by choosing several learning experiences in each level, gradually gathering an increasing number of BitPoints (Figure 4). After the initial experience on level 1, they even tried the highest level of difficulty. Then, when other subjects started to request further dedication from them, the number, diversity and difficulty of the learning experiences reduced.

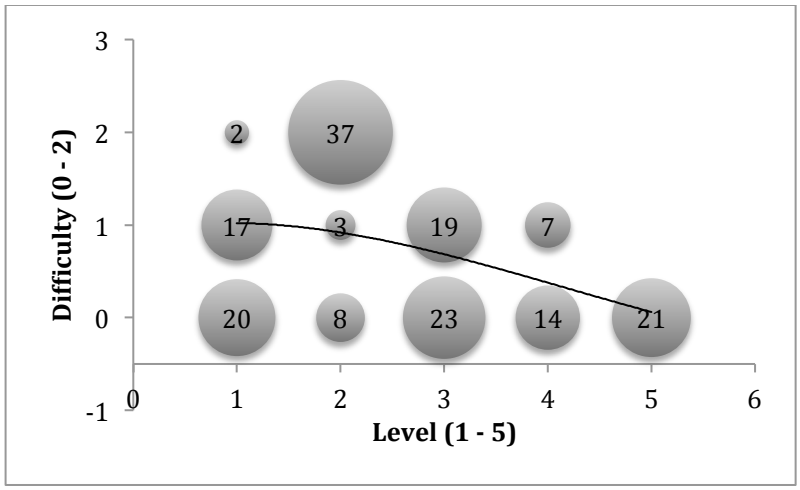

Figure 4 – Difficulty of learning experiences with the level.

Each learning experience had a specific due date. Although several students managed to finish before the due date, others chose to ignore this deadline and delayed several days (Figure 5).

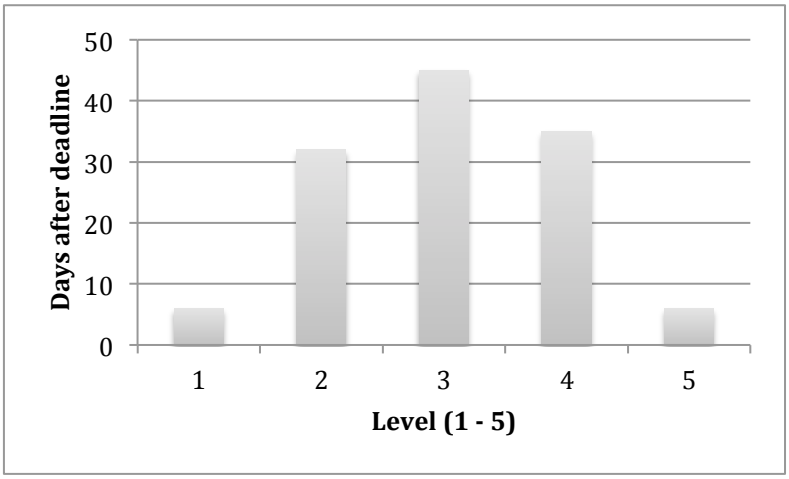

Figure 5 – Days after deadline in each level.

Finally, a questionnaire was presented to students for them to evaluate the evaluation methodology. 71% of the students said that they strongly preferred this assessment methodology when compared with traditional exam based assessment. When the student chose the hardest learning experiences, the reason was to achieve a higher grade (78%) and when choosing an easy learning experience, the reason was slightly motivated by ensuring success to the subject (33%). Overall, they found the assessment system adequate (78%). Most importantly, they concluded that the possibility of choosing the learning experience difficulty in each level contributes to autonomy and motivation (83%).

5 CONCLUSIONS

In the context of higher education, a gamification approach was followed, structuring a subject around the concepts and mechanics of games. This included the definition of games as learning experiences, together with traditional practical assignment exercises, as well as the definition of a grading and assessment system based on an award mechanism. The award mechanism provides a mean for the student to be constantly aware of the progress within the subject as well as the instantaneous success. The existence of such assessment system is fundamental to the motivation of students. It provides a grading mechanism as well as a base for levels and adaptive challenges on the form of a set of learning experiences that the student can choose from.

In traditional, exam based grading and assessment, students are usually compelled to study and prepare themselves to pass the exam. The learning occurs, mainly, in this process. The award system described in this paper is distributed, meaning that the student is constantly being assessed and graded, motivating them to spend more time and energy learning and organizing the skills they are acquiring.

Moreover, the possibility to choose from a set of learning experiences also contributes to some curiosity, in the sense that the student is a little uneasy, regarding the choice made: is this the best learning experience for me to do? This restlessness further contributed to more participative and dynamic classes, with the effect of including more students and pushing learning further.

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