E-learning-oriented incentive strategy: taking EduPCR system as an example

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ABSTRACT: Increasing attention is being paid to incentive mechanisms in e-learning. In this article, the authors have proposed a taxonomy of incentive strategies in the context of an information system, EduPCR, dedicated to the learning of programming. All strategies are classified into four categories, including achievement, ability, environment and material. In addition, an incentive strategy model is put forward, including technical and management strategies, through time nodes in the whole learning process. The incentive strategy model, based on the EduPCR system, was tested at a Chinese university. Through a questionnaire and interview, the data show that the majority of students are much interested in the incentive model and believe that it does help them to improve their programming skills.

INTRODUCTION

The cultivation of students' ability to learn and practise is of great concern [1]. For instance, in programming courses, students will well acquire knowledge through practising to program. However, they may feel bored by repetitive or similar tasks. This suggests the way to teach and examine should be reformed to raise students' interest and promote their effective learning. Reported in this article is an e-learning system based on a peer review process and the incentive strategy for its use.

Many scholars have studied the way learning on-line takes place, such as the acceptance of e-learning, key motivating factors and so on. Liao et al find that individual factors (performance expectations, effort, behavioural factors), and group-level factors (colleagues' influence) have a positive effect on behaviour [2]. Law et al believe, it is important for educators to empirically and systematically identify the set of factors that motivates the learning of their students [3]. Wu et al study the quantitative evaluation of e-learning users' psychological experience, and have analysed the influence of features, such as ease of use, usefulness and emotion, on users' psychological experience [4]. Turner et al use peer review exercises in two classes a semester at neighbouring universities. The result points to there being a lack of motivation to review peers and highlights the need for external motivation and for monitoring of the process [5]. Zhang et al reports on an incentive strategy for students on software engineering courses, which is based on group learning [6]. However, there are few publications on a complete incentive strategy for learners using e-learning.

The information system outlined in this article is based on the peer review model [7]. In the system, students play the role of both authors and reviewers. There are five phases in it, including writing source code, reviewing, revising, checking marks and final evaluation [8]. Peer review means the users review other students' programs, give advice and grade the source code. Some available incentives for e-learning are provided in this article, based on the EduPCR system. The incentives improve students' learning efficiency and the learning outcome is satisfactory as well.

TAXONOMY

The taxonomy of the incentive strategy is depicted in Figure 1, which includes four categories of incentive mechanism: achievement, ability, environment and material.

Achievement Incentive

It is obvious that a high-level of achievement can make students enthusiastic to study. However, it needs to be fair. There are three incentives to this aspect, including peer assessment, the exhibition of excellent programs and a learning curve to display progress.

1. *Peer assessment.* In the EduPCR system, each student plays the role of author and reviewer. They are authors who submit manuscripts and revise programs. In addition, they are reviewers who review others' manuscripts.
2. *Exhibition of excellent programs.* Each time students submit their revised manuscripts, the instructor will choose the best program as a sample and display it on-line through the system.
3. *Learning curve.* Learning curve is a line graph where students can see their grade, the top grade, the bottom grade and the average grade of each assignment. The grade is the y-axis and the assignment number is the x-axis. All in all, it consists of four lines differentiated by colour.

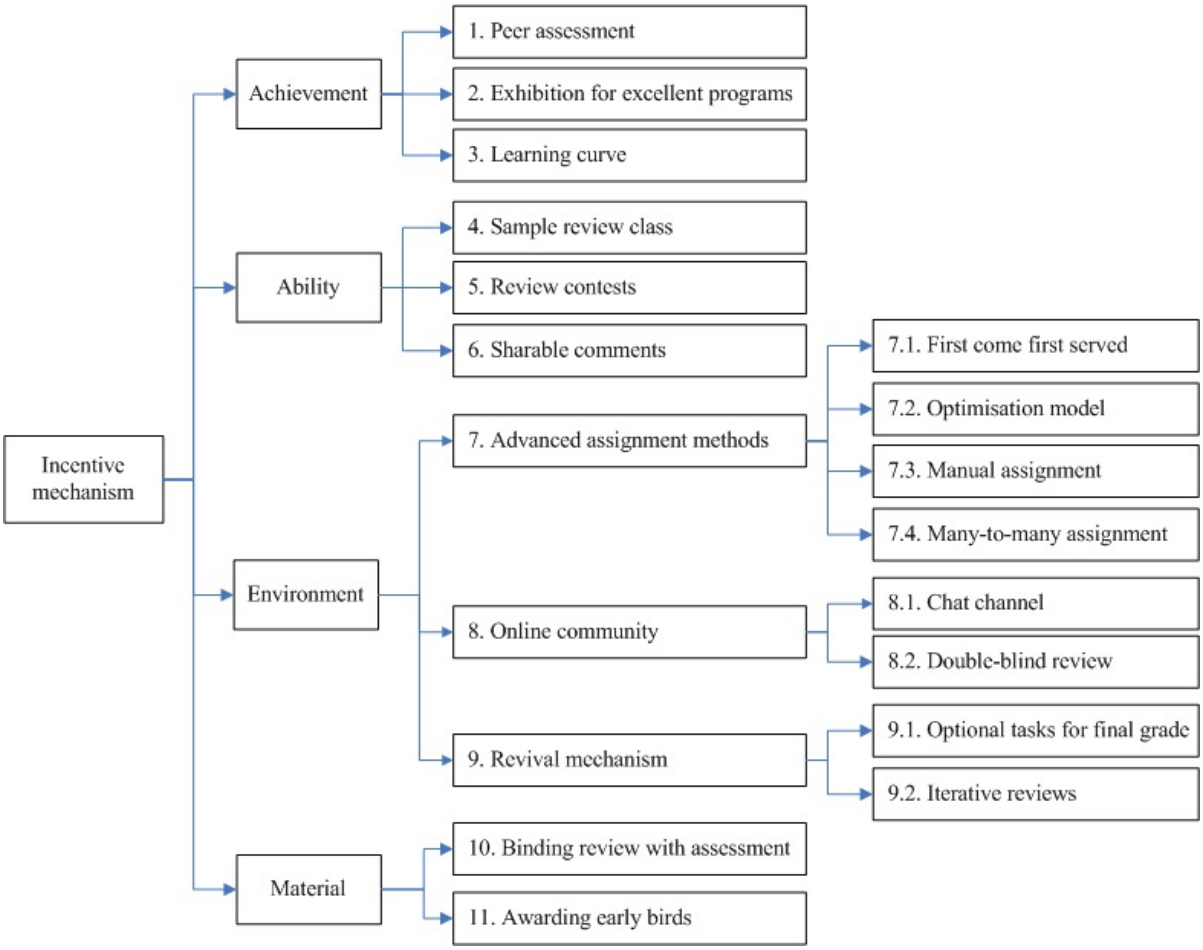

Figure 1: Taxonomy of the incentive strategies.

Ability Incentive

The purpose of the EduPCR information system is to raise the ability of students. For this, the incentives are sample review class, review contests and sharable comments.

1. *Sample review class.* In the sample review class, the instructor chooses one or more typical programs as samples, and leads students to evaluate and review them together. They can run the program, ask questions and compete to answer the questions. During the class, the teacher will discuss the evaluation.
2. *Review contests.* The pattern of a review contest is much like a test, in that students get together to review one program in a limited time. The instructor will evaluate their reviews and reward those that are excellent.
3. *Sharable comments.* This is a many-to-many assessment process in which a reviewer's assessment of a program will be visible to other reviewers of the same program, with the evaluations being distinguished by colour. This avoids repeated assessments, and also promotes reviewers' mutual learning.

Environment Incentive

The environment incentive can promote self achievement of students and stimulate their interest in learning. The EduPCR information system includes advanced assignment methods, an on-line community and a revival mechanism.

1. *Advanced assignment methods.* a) *FCFS (first come first served)*: the system will process submitted assignments by assigning reviewers to the authors automatically and efficiently [9]; b) *Optimisation model*: students are divided into groups and assigned according to their programming ability; and c) *Many-to-many assignment*: each author's program will be reviewed by multiple reviewers and each reviewer will review multiple programs.

2. *On-line community.* a) *Chat channel*: in the review process, authors and reviewers can chat through the chat channel any time they have trouble with the program or the evaluation; and b) *Double-blind review*: authors and reviewers cannot know each other's name because each of them is named anonymously by the system through the Web window.
3. *Revival mechanism.* a) *Optional tasks for final grade*: every student does 12 tasks, but in the final of a term they can choose the best 10 tasks to constitute their final grade; b) *Iterative reviews*: students can start the review process again and again after they revise their manuscript before they actually submit their final manuscript before the deadline.

Material Incentive

Effective material incentives can encourage students to make an effort to achieve the tasks. In this respect, it involves reward and penalty. These incentives are the *Binding review with assessment* and *Awarding early birds*. 1) *Binding review with assessment*: the quality of review will be considered in the assessment. 2) *Awarding early birds*: to motivate students to submit tasks early, they are rewarded through the scoring when submitting their tasks before the instructor's set time.

METHODOLOGY

The incentive strategy model is depicted in Figure 2; the numbers denoting strategies can be found in Figure 1.

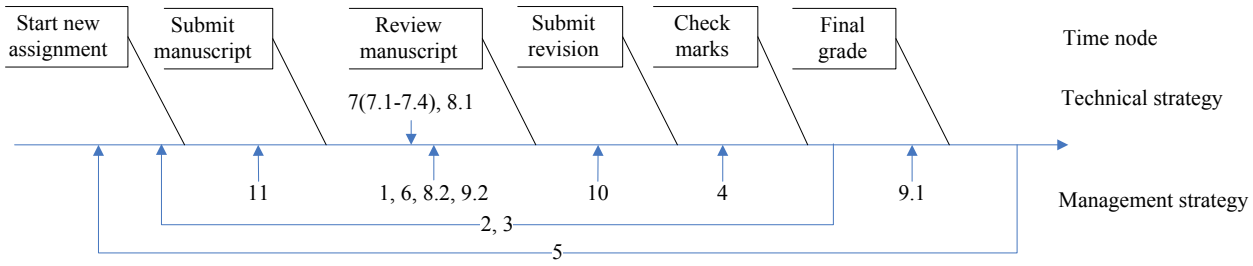

Figure 2: Incentive strategy model.

Stage 1 lasts from the teacher assigning homework to students' submitting manuscripts. The incentive, *Awarding early birds,* is used to encourage students to finish the task early and to actively review their knowledge, from a management perspective. As expected with the aggressive mentality of some students, many would hand in their tasks early to get awards. In order to finish the tasks as soon as possible, they would need to be timely in reviewing the knowledge learned in class.

Stage 2 lasts from students' submitting manuscripts to submitting review results. These incentives consist of technology strategy and management strategy. Technology strategy refers to technology-based improvements in the system process, including *FCFS, optimisation model, manual assignment* and *many-to-many assignment.* Management strategy includes *peer assessment, sharable comments, double-blind review* and *iterative reviews*. The four assignment strategies are not contradictory. The system generates the assignment results using *FCFS* or the *optimisation model*, and the two can be combined. That is, the system assigns the manuscripts in groups every once in a while and each group is assigned an optimisation model. In addition, *many-to-many assignment* is not confined by the system's automatic assignment or manual assignment. The limit on the number of assignments is set by the teacher. The flexibility and adaptability of the system can be improved by combining different assignment strategies.

1. *FCFS.* Students with a positive attitude tend to hand in their tasks early. The majority of students who hand in tasks early have a high level of programming ability. All the students hope that high-level students review their manuscripts, which will mean they may obtain more valuable comments. Since *FCFS* divides students into groups according to the submission time sequence, students need to hand in their tasks as soon as possible to increase the possibility of being in the same group as the excellent reviewers. Thus, this method improves learning efficiency by motivating students to finish their tasks faster.
2. *Optimisation model.* Through the optimisation approach, the resources of the participant are put to good use. It not only gradually raises the student's ability to program, but also improves their whole level of learning. Besides, teachers can change the optimisation model, as required by the teaching.
3. *Manual assignment.* Since the number of reviewers is limited and students are assigned a reviewer after they hand in their manuscripts, they must hand in their tasks quickly to find good reviewers. They are encouraged to improve their learning through this pressure. Moreover, most of the reviewers assigned have better programming skills. Thus, the reviewer would feel proud of himself/herself and, thus, improve his/her interest in learning.
4. *Many-to-many assignment.* This extends the scope of review and contributes to students' enthusiasm, while motivating them to finish tasks early. Since there is a limit on the number of excellent students, the earlier a task is submitted, the more likely it is to be assigned an excellent reviewer. Authors can better revise their programs if it

is reviewed by more than one reviewer. However, there are more reviewer's tasks for students in the *many-to-many assignment*, which is likely to cause a backlog. In order to reduce the completion time of each job, teachers should limit the maximum review tasks for each person.

5. *Chat channel.* The chat channel provides a way for the author and reviewer to communicate when the reviewer has a problem understanding the code, or the author has some trouble with the reviewers' comments. As a result, the possibility of a low score on either or both sides, due to misunderstandings, will decrease.
6. *Peer assessment.* Students have the same opportunity for review which shows the equality of the system. The process of review allows student reviewers to learn to treat programs critically. In this way, they become aware of their own problems while making suggestions. Moreover, the co-operative learning model should strengthen their sense of pride and confidence.
7. *Sharable comments.* It is obvious that this method increases difficulty of reviewing. Students who have a poor ability in reviewing will need to complete a review as soon as possible or they may obtain a low grade because of making fewer suggestions. This raises the efficiency and positivity of reviews by exerting pressure on the reviewers. As for the students with high ability to review, this process increases the challenge of the review, which can enhance their interest in reviewing.
8. *Double-blind review.* This makes students more relaxed in the process of review. For one thing, their anonymity means they do not need to worry about losing face through making wrong suggestions. For another, reviewers do not need to consider interpersonal relationships while grading. The incentive system reduces students' pressure so that students are willing to review.
9. *Iterative reviews.* If the interval between the accomplishment of the first-round review and the deadline for the task is long enough, the author can have several rounds of review. The form of review can be assigned by the system based on the reviewer resource. Therefore, authors can receive more advice, which allows them to realise any profound problems in their program. Also, they can learn review skills from reviewers, which will improve their own abilities. For those wanting a multi-cycle review, they must finish their tasks as soon as possible so there is enough time.

Stage 3 lasts from submitting review results to submitting revisions. An incentive, *Binding review with assessment*, is proposed, which encourages students to treat the review process seriously. During the assignment process, the quality of manuscripts and the level of review results, should be evaluated in the form of process points. Therefore, the mark for a task is calculated as the sum of *process points*, *reward* or *penalty points*, and *quality points*. The process points are obtained if the students submit both the manuscripts and the review results. The reward points can be obtained by the student if they finish the manuscripts with serious intent or review the codes responsibly. By contrast, if students finish the manuscripts poorly or review the codes carelessly, they will be penalised. A strict penalty can disqualify students who finish the manuscripts poorly or review the codes carelessly, more than three times.

Stage 4 lasts from submitting revisions to the grading task. It is worth making full use of the time in this stage to make students understand the details of the standard for evaluation, as this can help them to better understand their program. Hence, a sample review class is proposed with a management perspective. According to the achievement of the tasks and students' suggestion, the sample is selected by the teacher before the review contest. For instance, if the task is difficult or the achievement of most students is unsatisfactory, the best programs will be selected as the sample to make the students learn from these programs. By contrast, the inferior programs also will be selected, as these can raise the students' awareness of their weaknesses. Because of differences between individuals in levels of thinking and understanding, a collective review can develop divergent thinking in students. As well, the process of group discussion helps students develop interest.

Stage 5 is a phase where students obtain the final scores according to the task scores. The incentive of this stage is *Optional tasks,* which also is a management incentive. The functions of this method have two aspects: a) to keep the students enthusiastic instead of losing their confidence because of the unsatisfactory achievement of one task; and b) if the final score is relatively high, it will enhance the student's sense of accomplishment.

Whole Process runs through the five stages mentioned above. The teacher is allowed to start a review contest during the whole stage. The functions of this incentive are related to honour and ability. The honour is high praise, which can satisfy students' self-esteem and stimulate them to become better. Giving a title to the winner will push students to win and inspire their enthusiasm to review. Moreover, students can study independently and realise their potential, thus, improving their learning ability.

INVESTIGATION

To research the acceptability and applicability of the incentives above, a survey was carried out among the students of the EduPCR system: the undergraduate students in Year 1 through Year 4 majoring in Information Management and Systems at the Harbin Institute of Technology in the People's Republic of China. The survey included an interview and questionnaire filled with single-choice questions. In total, 104 copies were delivered, and 94 valid copies were received. The content is all about the acceptability, and user-perception of, the incentives, such as peer assessment, the form of assignments and so on.

In *Stage 1*, students had different opinions on the incentive, *Awarding early birds*: 47.3% of the students consider that if there are some rewards for the students who submit the programs early, they may finish the task quickly and excellently; 47% of the students thought it had no effect on them; 5.4% of the students believed they should submit the programs as quickly as possible to gain the rewards, without regard for the program's quality. The conclusion is that this incentive is accepted by only about half of the students. Why is this so? First, students with good programming abilities may regard the quality of the program more important than the reward. Students with lower programming abilities can accept the method more easily because they hope to gain the reward scores. Second, students understand this method only in theory. After all, it has not been put into use in the EduPCR system.

In *Stage 2*, eight incentives were surveyed and their results are listed as follows:

1. *FCFS.* In the survey of *FCFS*, 57.6% of the students elected to submit the program as quickly as possible in order to enter the process of review faster; 37% of the students considered it had no effect on them. Only 5.4% of the students would submit the programs at the last minute. The conclusion is that *FCFS* can increase most students' efficiency.
2. *Manual assignment.* According to the inquiry, 63% of the students said they would finish the next work as early as possible to get priority options; 26.1% of them said they did not care who reviews their programs and the remaining 10.9% complained that the system was unreasonable. This shows that the limited resource of reviewers can urge authors to finish programming tasks as fast as they can.
3. *Many-to-many assignment.* About 73.4% of students preferred the *many-to-many assignment* as compared with the one-to-one assignment, although there is a significant increase in student workload. It shows that most students are willing to accept more reviewing work, so as to obtain more knowledge. In the *many-to-many assignment*, authors can obtain many different reviewers' assessments and adopt their useful suggestions in revising their programs. Reviewers can improve their skills by reviewing other students' work and in the process learn more about programming from the different authors' programs. In a word, it can effectively improve students' programming skills.
4. *Chat channel.* Because the EduPCR system offers differing versions for use by respondents, it was assumed the system had a *chat channel* function. The result of the survey shows 90.4% of the students said it made them review their work more seriously and 6.4% thought the *chat channel* function had no effect, while only 3.2% would not use it to review the program in a serious way. Generally speaking, the strategy can encourage students to treat the reviewing process seriously rather than perfunctorily. According to the interview, most students said they would patiently ask the reviewer to explain, if they could not understand the comments, and they would treat authors' questions similarly in a serious and patient way. The *chat channel*, by encouraging students to learn through co-operation, strengthens the understanding of what they learn.
5. *Peer assessment.* As for the students acting as authors, 61% of them believe it gives them a sense of achievement when the reviewer assesses highly. Otherwise, 30.9% of the students simply would look at the assessment and revise their program and continue to study seriously. Only 7.4% of the students did not care. As for the students acting as reviewers, 53.2% of them believe that if they obtained high assessments from the authors, they would feel successful and, if not, they would consult teachers' reviewing skills; 37.2% of the students would only take a simple glance at their assessments. Only 9.6% of students said they did not care. From the data above, the majority would like to revise their programs according to their assessments and more than half of the students would correct the faults. The peer co-operation process can encourage students to study independently.
6. *Sharable comments.* In the survey, 57.4% of the students approved of this and 12.8% of the students held a neutral attitude; 29.8% of the students expressed disapproval of it. Compared to other incentive strategies, this mode was opposed by more students because of a difficulty in terms of review. The demands of this mode adds pressure to students, which may lead to a negative reaction.
7. *Double-blind review.* During the interviews about the double-blind review, it was found that most of the students think that: a) they do not need to worry about making inappropriate comments, and can be free to review; b) by not having to consider their relationship to the student, they can review more easily; while a small section of the students believe that adopting the real-name-system will stimulate them to finish the manuscript more attentively and review others' programs more responsibly. Overall, the double-blind system has gained the approval of the students. It allows students to comment more equitably on each other's work, while reducing the pressure from reviewers' comments.
8. *Iterative reviews.* In comparing the single-cycle review with the multi-cycle review, the number of students who prefer single-cycle reviews (41.9%) is similar to those who prefer multi-cycle reviews (58.1%). This is because the multi-cycle review is aimed at examining the program thoroughly. However, since the multi-cycle review is begun by an author after receiving all review results, it takes a relatively long time to accomplish. Students have differing aims and attitudes, which leads to the result.

In *Stage 4*, as for the sample review class, 68.5% of the students hope their program code is chosen to be the sample; 28.3% of the students have a neutral attitude and only 3.3% do not hope theirs is chosen. It can be concluded that most students accept and support the sample review class. Through the study of the curriculum, they hope to solve their own problems from the sample program and to learn from it. They can learn to think about questions from different perspectives and improve programming through brainstorming. Finally, the sample review class can satisfy the students' desire for knowledge and encourage them to be interested in study.

In *Stage 5*, the data about the learning curve show that 55.3% of the students hope the EduPCR information system will show the scores by way of a learning curve and 17% of the students choose the answer, *very hope(ful)*; 22.3% of the students hold an opinion on whether to display the learning curve, while only 5.3% of the students do not expect to do so. According to the results of the survey, 49.5% of the students think the design of the learning curve is reasonably effective in checking the changes in their scores and study plan. Also, 35.2% of the students believe they can find the learning gap between themselves and others, which can encourage them to work hard. Only 3.3% of the students think it has no effect on their study.

It can be seen that most students are willing to accept the improvement of the EduPCR information system with the learning curve. It is obvious that the learning curve acts as a *supervisor*, in that it encourages the students in the study process. In the sample exhibition survey, most students (54.3%) hold a neutral opinion about selecting the best code for exhibition on the EduPCR Web site; 27.7% of the students think it is necessary while 14.9% of the students think it is unnecessary; and even 3.2% think it is totally unnecessary. There are few students who hold a negative attitude. It was concluded that this method can improve the programming ability of the students by exhibiting the work of the best students. Although they did not express strong support; 61.7% of the students hoped their code would be exhibited and they felt proud about it; but 5.3% of the students did not hope their code would be exhibited. Finally, it can be said that this educational method did not repel students; on the contrary, it can inspire them to do their best.

As for the *Whole Process*, it was found that the way the final scores from the optional tasks are counted is totally supported by the students. They believe it is obvious that this incentive strategy relieves the pressure of study, because they do not think negatively about an unsatisfactory task. As well, there is no great change to the final scores, if they must give up a very difficult task. Moreover, in the survey on the effects of the review contest, 22.8% of the students believe it can improve their interest in reviews, and 47.8% of the students think they can acquire more knowledge through the contest. A percentage of students (23.9%) believe it has no effect on their programming language study, and 5.4% believe it is totally a waste of time. Students hold different opinions as to the effects of the review contest. However, they do support the contest and expect to gain more knowledge about reviewing and programming skills through this format as a whole.

CONCLUSION AND FUTURE WORK

Through the questionnaire and the interview, it is obvious that the incentive strategy is widely accepted by students. They are very willing to accept the EduPCR information system. Moreover, with the improvements introduced, of procedure, rewards and penalty points, as well as a co-operative approach to learning skills, most students believe it can help them to improve their abilities and improve self-achievement. Through environmental and material incentives, students can learn positively and pursue consistent improvements in personal ability.

In this study, the model designed was purely using the EduPCR information system and all the incentive strategies in the model are qualitative research. Future work may cover the following aspects: 1. *Beyond the EduPCR:* the authors hope their contribution could be applied to other contexts, such as the adoption of an information system and co-operative learning; and 2. *Empirical analysis:* in the future, each incentive should be studied by designing a formal experiment, collecting accurate data and analysing the results with well-accepted methods.

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