Mechanism Design on Coursework Grading to Create Incentives for Student Learning

Julita VASSILEVA[a]*, Ralph DETERS[a], and Jie ZHANG[b]
[a] *Computer Science Department, University of Saskatchewan, Canada*
[b] *Nanyang Technological University, Singapore*
*jiv@cs.usask.ca

Abstract: In this paper, we discuss some issues of extrinsic motivation in learning and argue that mechanism design can be applied on coursework grading to create incentives for student learning. We present an exploratory study using non-graded coursework in two fourth year university classes. Based on the study results, we discuss and suggest some important factors that influence students' learning motives and that need to be taken into consideration for designing a proper coursework grading mechanism.

Keywords: Computer Aided Education, Mechanism Design, Incentives for Learning

Introduction

Learning can be made more engaging and gratifying through games. Games provide a combination of challenge, achievement and reward, which motivate intrinsically the players by allowing them to hone their skills. Games provide also extrinsic/social incentives, through engaging the players in competition with others and allowing them to build reputation. Finally, game performance may be related to some real world rewards, if translated into currency or grades. We argue that coursework can be regarded as an educational game, which involves challenges (assignments, projects, essays that the students need to do), and the corresponding rewards for overcoming these challenges (grades and relative importance/weight of each challenge).

In our experience, university students are strongly motivated to achieve high grades in their classes. They play the game, i.e. do the coursework, in order to learn, and also to earn the rewards. Teachers define the challenges and the corresponding rewards (grades), so that they can engage students in meaningful learning experiences through the term and thus prepare them for the exams. Designing both a good game and good coursework for a class requires careful design of the challenges and rewards provided. Certainly following educational principles and knowledge of the domain is necessary in the selection of the challenges. For example, the challenges have to be adjusted to the gradually increasing skill level of the player/learner.

In the current practice of designing university class coursework, teachers select rewards for overcoming each challenge (e.g. assignment, project or participation) in an ad-hoc manner, following some general university guidelines. For example, the weight of the final exam cannot be more than 50%, or the majority of the final grade should be earned in coursework during the term. A typical course grading scheme at our department, for example looks as follows (in this case taken from the Social Computing Class course outline): 2 assignments (worth 10% of the final grade each), Course project (worth 25% of the final grade), Class participation (worth 5 % of the final grade) and - Final exam (worth 50% of the final grade). One can easily imagine an alternative grading scheme, for example: Preparing 2 class presentations on selected topics (worth 15% each), In-depth review paper on a selected topic (worth 30%), Course project (worth 35%), Participation in class discussion (worth 5%)

While the second grading scheme seems more typical of graduate-level classes, it may be suited well to some undergraduate students. Providing alternative activities within the coursework that students can choose to take allows for multiple possible alternative paths towards the goal and opens the possibility for personalization in traditional, classroom environment.

When designing such coursework grading schemes, a crucial decision is the reward (or grade percentage) offered for each activity/challenge. If we assume that students are economically motivated and with limited resources (time, shared between the courses they are taking), they focus most of their energy on the challenges that offer the greatest rewards. It is important therefore, that the activities/challenges that would provide the biggest learning benefits, are assigned the highest rewards.

However, students may not be entirely driven by grades, and (hopefully), there are always some students driven by intrinsic motives, like desire to learn, wish to impress (the teacher or peers), or wish to help others learn. Activities that provide additional rewards of this kind involve some kind of public space and collaboration, e.g. participation in online discussion forums or in class discussion, in wikis, and doing team-projects. These activities may be intrinsically rewarding and may not need to provide high rewards in terms of marks. Course designers may wish to keep high grade weight as reward for unattractive and hard challenges, which have a high learning value. A course designer may look for inspiration into economics and game theory. The area of mechanism design deals specifically with the question of how to set the rewards for particular actions/challenges, to ensure a "fair" game and individual player behavior that satisfy certain goals of the designer (e.g. putting more effort in certain activities than others).

1. Mechanism design

Mechanism Design is the branch of economics that is concerned with designing the rules of interaction (game) that achieves a specific outcome even when the participants are self-interested. This is done by setting up a structure in which each player has an incentive to behave as the designer intends. The game is then said to implement the desired outcome. There are many applications of mechanism design: the design of auctions, matching algorithms, such as the one used to pair medical school graduates with internships, the provision of public goods and the optimal design of taxation schemes by governments. The task of designing a mechanism in learning/educational setting needs to consider the utility or the personal goals of learners. Students are clearly motivated by extrinsic factors - getting a credit, certification, or just a higher grade in class. Yet, they are also motivated by intrinsic factors - wish to learn, self-efficacy [1]. Apart from these two main motivations, students may be motivated by social factors - a wish for peer- or teacher-recognition, or earning high reputation in the group (socially motivated). They may be driven by a goal to help others, e.g. to learn knowledge so that they can explain it to their friends, to reciprocate or to build new relationships through collaboration with others.

In our previous work, we have explored the use of incentive mechanism design that rewards students' contributions in a shared class resource repository and participation in a discussion forum (considered beneficial for learning) with reputation, status in the group, and immediate pleasing effect that emphasizes the individual contribution to the community [5]. While not providing differential marks for participation in these activities, we have observed significant increase in participation (nearly 100%).

Designing an incentive mechanism involves two important parts: 1) defining the payoff matrix which rewards for particular actions/challenges, and 2) communicating the results of the game to the players on an ongoing basis. The rewards have to be aligned with the individual learner's goals, but also with the teaching goals of the instructor and certain

social/community goals (e.g. to ensure fairness). For example, rewards in terms of points for contributing posts to a discussion forum align with the learner's goal to earn recognition among his or her peers, but also with a teaching goal to stimulate discussion on a topic and a social goal – to ensure a certain level of participation in the forum so that it is attractive to the learners and they come back to check it regularly. Communicating the performance results back to the players/students rewards and motivates them and allows them to correct their behavior so that they can achieve their goals. For example, publishing the reputation ranking in a discussion forum or the assignment marks rewards students who are motivated by personal achievement, those motivated by reputation, (i.e. those who want to impress their fellow students and the teacher). However, it may intimidate students who didn't do well, and those who do not want to be seen as too eager to impress.

Game design involves also for "maintenance" activities that need to be completed but do not carry particular rewards. These activities may be needed to prepare to perform well on other, highly reward activities (e.g. the final exam). In some sense all of the coursework activities listed in the two examples given earlier could have been considered "maintenance" activities that prepare the students to perform well on the final exam. In fact, many European Universities do not assign graded coursework to students during the term, the final exam is worth 100% of the class grade (or there are two exams, worth 50% each). The students are expected to find ways practice their skills and prepare for the final exam on their own and receive no rewards for this in terms of grades. It is somewhat unusual, however, in a North American university context to think of assigning coursework, which does not bring rewards towards the final course grade. In the next section we describe a small experiment that we carried out in two classes taught at the University of Saskatchewan in the fall of 2008 to explore if the two parts of a mechanism design listed above are important in the design of coursework.

2. Mechanism Design in Grading Coursework

The classes were Mobile and Ubiquitous Computing (MobUbi) taught by one of the co-authors and on Social Computing (SocComp), taught by another co-author. Both were 4th year undergraduate Computer Science classes, with 11 and 10 students, respectively. In both classes the instructors considered writing of a half-page summary of the material covered each week to be a valuable learning experience. Both classes had no textbooks; a large amount of material was covered; and it was challenging for students to select the most important information to remember for the final exam. The summaries could be useful in preparing for the final exam, since otherwise the amount of material and details would be overwhelming. So the instructors decided to add "weekly summaries" to the list of activities in the coursework and decided to experiment if the students will complete the summaries if there was no direct reward in terms of percentage of the final grade for doing the summaries. To create an indirect incentive for doing this activity, the students were allowed to take the summaries in the final exam (i.e. the exam became a semi-open book). The mechanism of the activity of submitting the summaries in the two classes was different, as explained below.

In the MobUbi class, each student had to submit an individual summary by the end of the week. In the final examination, each student received a printed copy of all of their own summaries. In this way there was an incentive for students to do their best when writing the summary. After the strict weekly submission deadline, everyone could see all submitted summaries, and compare their own summary with those of others. In this way, students had access to other viewpoints of what was most important, and could prepare better for the exam. Also since the exam was the highest rewarded activity, the expectation was that the students will invest effort in doing good summaries so that they can bring in the exam a good "cheat-sheet".

In the Social Computing class, where some of the class topics covered public goods, the tragedy of commons, collaborative knowledge production in Wikipedia and online communities, the instructor decided to involve a collaborative style of writing the summaries, using a wiki. To illustrate the concept of "tragedy of commons" in practice, and to eliminate other social motivators (attempts to earn reputation or impress the instructor), the instructor set the wiki so that it did not require login and there was no way for the instructor or the other students to know who had contributed and if they had - to which part of the summary. In the final exam everyone would receive a printed copy of each weekly summary (generated collaboratively). The expectation was that even though there was no direct personal benefit from participation and no public knowledge of one's involvement, the students would contribute and collaborate for the common good and will produce summaries that are better than individual summaries, reflecting a multitude of viewpoints. In this way they will all have a good starting point in the exam.

Table 1. Weekly contributions in two fourth year undergraduate classes at the Computer Science Department, University of Saskatchewan, fall 2008/2009.

Week of the Class	Social Computing Class (10 students)	Mobile & Ubiquitous Computing (11 students)
Week 1	6 users (last 3 before the exam)	7
Week 2	6 users (last 3 before the exam)	4
Week 3	3 users (last 2 before the exam)	4
Week 4	2 users (last one before exam)	4
Week 5	3 users (last one before exam)	1
Week 6	2 users (last one before exam)	3
Week 7	2 users (last one before exam)	2
Week 8	2 users (both before exam)	2
Week 9	2 users (both before exam)	0
Week 10	2 users (both before exam)	0
Week 11	1 user (before exam)	0
Week 12	1 user (before exam)	5

The results showed that the indirect reward (increasing the chances of doing better on the final) was not strong enough to motivate students to do the extra activity. The declining time pattern of contributions was similar in both classes (see Table 1). The number of students submitting summaries in the MobUbi class dropped down to 0 and only in the last week of the class it went up again. In the SocComp class we saw much lower participation. Three students participated in the writing of the weekly wiki summaries in the first 3 weeks, and after that only one student remained active; he wrote all of the wiki summaries for the next 7 weeks. Only after the end of the term, just before the final exam, another couple of students participated to revise some of the summaries. Of these, one student did minor changes (word swapping) in all of the summaries. This student was the sole author of the last two summaries, which were plagiarized from the course notes (the entire text was copied, with no line breaks). Apparently, this act of gaming was a result of desperation by an unprepared student, who was hiding behind the anonymity of the wiki.

We repeated the experiment in the next year, 2009/2010 in the same classes, with comparable numbers of students in each class. This time students had to log into the Wiki used in the Social Computing class, so it was visible who participated in writing the collaborative summaries. Nevertheless, not a single summary was started for the entire term! Not even in the days immediately before the final exam. It is hard to explain the students' disinterest in helping themselves do better on the final. On the contrary, in the MobUbi class with the individual summaries, most students submitted summaries on time for each week.

3. Discussion and Future Work

While the results show that rewards in terms of marks are the most important incentive for students to do coursework activities; when no marks are awarded, students do not do the work. This is easy to explain [3]: students are very busy and focus their attention where they get immediate payoff. Even if they understand the long-term/postponed benefits of doing an activity, they may not do it, if there is no perceived threat (e.g. a looming deadline). Our hypothesis for the better success of the no-rewards activity in the MobUbi class is that students, who have so many demands on their time, grow increasingly deadline-driven. They would do the activity if they may lose the chance to do it later (as the deadline for submitting summaries in MobUbi was strict). Students in the SocialComp class procrastinated for too long and in the end of the term the task appeared too enormous to complete for any single individual, so no one attempted to work on it. Other factors that may have influenced the students' motivation are probably: 1) *Direct personal benefit* - in the MobUbi Class a student could benefit only from his/her own summary, while in the SocComp class the work of one student benefitted everyone. Apparently, working for the public good is a rare phenomenon when time is short. The student who contributed all wiki summaries was finishing his studies and this was his only class left to take. 2) *Social Transparency* - in the MobUbi class, it was clear who did not contribute (and the students possibly feared retaliation by the teacher), while in the SocialComp Class the anonymity facilitated the tragedy of commons effect, in the first experiment. These factors will need to be taken into consideration for designing a proper mechanism on coursework grading.

Mechanism design has also been widely applied in multi-agent systems. And, researchers have been developing multi-agent systems to deal with the challenges in educational environments [4]. However, none of them use mechanism design in multi-agent system based education. For future work, we will further explore the direction of mechanism design in a multi-agent based education environment where automated mechanism design [2] can be applied to elicit student learning, and where students can also be assisted by intelligent agents to make informed decisions about, for example, how much time should be spent on coursework in order to gain the maximum marks.

References

[1] Cheng, R., & Vassileva, J. (2006). Design and Evaluation of an Adaptive Incentive Mechanism for Sustained Educational Online Communities. *User Modelling and User-Adapted Interaction, 16*(2/3), 321-348.

[2] Conitzer, V., & Sandholm, T. (2003). Applications of Automated Mechanism Design. *Proceedings of the Conference on Uncertainty in Artificial Intelligence (UAI) Workshop on Bayesian Modeling Applications*. Acapulco, Mexico.

[3] Levitt, S., & Dubner, S. J. (2005). Freakonomics: A Rogue Economist Explores the Hidden Side of Everything. *William Morrow/HarperCollins. ISBN 0-06-073132-X*.

[4] Shi, H., & Shang, Y., & Chen, S. (2000). A Multi-agent System for Computer Science Education. *Proceedings of the Annual Conference on Innovation and Technology in Computer Science Education (ITiCSE), pp.1-4*. Helsinki, Finland.

[5] Vassileva, J. (2009). Towards Social Computing Environments, *IEEE Trans. Learning Technol. 1*(4), 199-214.