Lessons Learned from Introducing Educational Novelties in a Flipped Classroom M.Sc. HCI-HRI Course

Michalis Xenos
Computer Engineering and Informatics Department
University of Patras
Patras, Greece
xenos@ceid.upatras.gr

ABSTRACT

This paper presents experiences and lessons learned from introducing educational novelties into an M.Sc. human-computer interaction and introduction to human-robot interaction course. Toward this goal, the classroom is flipped, and the lectures are based on professor's short videos available online, following the blended learning model of a flipped classroom. The classroom is organized as a series of workshops and inside the classroom, activities focus on hands-on experience from using various tools and working on the human-computer interaction laboratory. The course includes activities for collaborative and project-based learning, role-playing activities and gamified activities, as well as more traditional activities such as debates and student's presentations. These activities are organized to engage students in creative design, interaction design, involving customers into the design process, and using analytic, laboratory and inquiry methods for the evaluation of their products.

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KEYWORDS
HCI course; blended learning; flipped classroom; collaborative learning; project-based learning

INTRODUCTION

Since software nowadays is developed so that can be used by anyone, anytime, and anywhere, human-computer interaction (HCI) education is changing in several respects [1]. The integration of core human-computer interaction (HCI) concepts, such as interface design and evaluation, into the computer science curriculum is not well anticipated. Such integration should balance effectively HCI theory instruction as well as hands-on experience. Nevertheless, at the end of the learning process, the students should be able to effectively use HCI knowledge to design and evaluate software. As a result, the teaching of independent and isolated conceptual entities, without offering a coherent conceptual context to provide the student the ability to create meaningful associations and abstractions and subsequently apply the obtained knowledge to increase the quality of interaction should not be considered as effective [2]. Additionally, teaching HCI is a difficult practice that has to evolve in response to changes in the technological landscape [3].

Today higher education in-campus students have a plethora of online tools in hand, that vary from tools used for communication and socializing to pure e-learning tools. Using such tools transforms their learning experience from a typical campus-based education model to a blended learning model [4]. With this in mind, a flipped classroom model [5] is used to teach an M.Sc. HCI course that hosts a small part of the introduction to human-robot interaction (HRI). During flipped learning the lecture is moved outside of the classroom, while inside the classroom the students perform activities. These activities are mostly group-based collaborative activities following learner-centered learning theories [6]. A flipped classroom, therefore, uses a learner-centered model in which the activities into the classroom explore topics in greater depth that students have already studied online.

This paper presents experiences and lessons learned from introducing such educational novelties into this course. The lectures were moved outside of the classroom, using professor's educational videos, while in classroom activities included students' presentations and debates, gamified creativity design, project-based collaborative interaction design including hands-on experience on evaluation in an HCI laboratory, using state-of-the-art HCI tools and gamified assessment. The rest of the paper is structured as follows. The following section introduces the M.Sc. course and the challenges, next we present the activities and the workshops of the course and we conclude by presenting the lessons learned.

THE HCI-HRI COURSE AND THE CHALLENGES

The flipped classroom course discussed in this paper is entitled "*Human's Interaction with Computers, Robots, and Smart Devices*" and it as a typical M.Sc. HCI course with a brief introduction to HRI, since there is a following HRI course. The M.Sc. program is the "*Computer Science and*

Engineering", an 18-month (3 semesters) program offering 90 ECTS (30 ECTS per semester) available at the Computer Engineering and Informatics department of the University of Patras. Students participating in this program are required to complete 12 courses and a thesis. The "*Human's Interaction with Computers, Robots, and Smart Devices*" course is a core (i.e. compulsory) course for the students of the division of "*Computer Software*" and an elective course for the students of the other two divisions ("*Hardware and Computer Architecture*" and "*Applications and Foundations of Computer Science*") of this M.Sc. program.

Normally 18 to 22 students are registered each year and the female/male ratio is around 1/4, which is typical for computer science programs in Greece. Challenges of this course are: a) educating a balanced audience which includes students from various disciplines (e.g. mathematics, computer engineering, and other engineering fields), with various levels of computer science background, b) being demanding to stimulate interest, but also not extremely time-consuming to facilitate working students (which due to economic crisis are the majority nowadays), c) adopt a project-based learning model that will introduce hands-on experience to students.

A course requirement from the M.Sc. regulations is that a student cannot miss more than 2 out of the 13 scheduled lectures. The formal lecture duration was scheduled for 2 hours, but during the first lecture is arranged to reduce the time of the workshops that are based on single-person activities and increase the duration of workshops that require collaborative project-based work. Therefore, the duration of the workshops varies from a little over 1 hour to 3 hours. The success of this course led into a new MHCI program that will accept the first students on September 2019.

THE WORKSHOPS AND THE ACTIVITIES

The course is designed to start with a short lecture, followed by discussions about the course per se on the first day and to continue with 12 workshops, each one every week with a short spring break for Easter holidays. In some workshops, students were required to undergo a brief pre-test to ensure that were prepared for the flipped classroom activities of the workshop. The first two workshops that followed the introductory lecture were focused on introductory to HRI topics, while the rest 10 workshops were focused on HCI topics. The educational material for this course was offered to the students online before each workshop. Such material was mainly short lectures from the professor, in the form of videos uploaded in the course's YouTube channel and documents delivered using the university's learning management system (LMS). The activities the students participate in this course are:

1. Debates (two teams) on issues related to the introduction to HRI on workshop 1.
2. Very short single student presentations related to HRI issues, followed by questions and discussion on workshop 2.
3. Gamified creativity design using Internet of Things (IoT) cards in small student groups on workshop 3.
4. Interaction design starting from mock-up screens and working toward working prototypes on workshops 4 to 7.
5. Inquiry methods for usability evaluation on workshop 8.
6. Efficiency of UI design on workshops 9 and 10.
7. Very short single student presentations related to further HCI issues, followed by questions and discussion on workshop 11.
8. Gamified review of the topics covered in the course on workshop 12.

Introductory Lecture

The first lecture is used for a brief (under 10 minutes) introduction to the course syllabus, while the focus of the lecture is to explain the flipped learning model to the students and organizational issues related to the course. Emphasis is placed on three items that are important for the success of such a course: a) engaging the students and convincing them about the added value of this method, b) relaxing their concerns about the effort required from them, and c) educating the students on how to study in a flipped classroom.

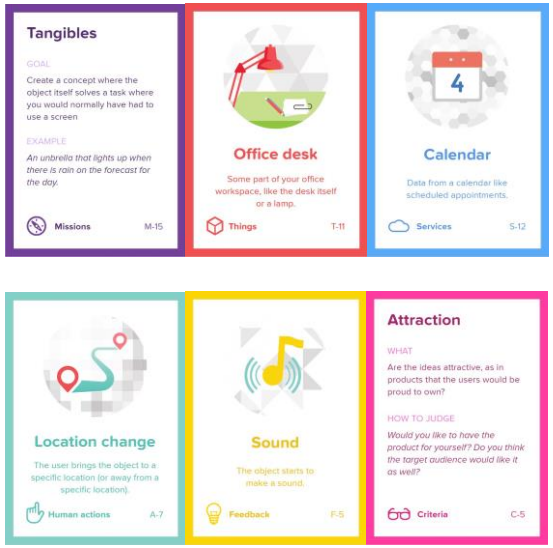

Figure 1: Examples of Tiles Cards, from left to right: Missions, Things, Services, Human actions, Feedback, and Criteria.

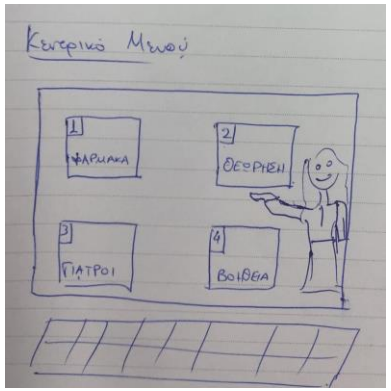

Figure 2: Mock-up screen from workshop.

Since the students of this M.Sc. program are not aware of the flipped classroom model, discussion focus on how this model works, why it is effective and what is expected from all course stakeholders. The typical students' concern is summarized in the question always asked: "*Do I have to work more than the usual?*". The students usually are convinced by the concept of having the course material available online anytime, anywhere, since most of them are working (at least part-time). To teach students how to study in a flipped classroom a funny origami video is used as an example. Students are handed origami papers and the professor starts a video explaining how to create an origami animal. Usually, most students fail to follow the video pace and stop. Then, during the discussion that follows, they mention that this is how they feel in most lectures. "*I wish I could pause the professor anytime I want*" a student commented. On this first lecture, we explain how critical is to properly study an educational video. We discuss how to pause the video and try to solve the example discussed in the video, having always nearby a pen and a paper.

Activity 1 (Debates) @ Workshop 1

For the preparation of the first workshop, the students receive the professor's videos (on the course's YouTube channel) related to the introduction of HRI topics. Some videos aim to stimulate questions about issues such as the technological singularity, the emotional vs. computational intelligent, the emotional robots, the robots for children, the laws of Asimov, and issues of trust and human fears of robots. The students must take notes on these issues and must bring their notes to the workshop.

This is a workshop lasting typically about 1½ hour, and during this workshop, students discuss these issues and then form two groups to debate for or against a point (e.g. if the technological singularity will occur soon). The professor chooses topics for which the classroom is split into two groups with an equal number of students. The two teams for each topic have time to choose their speakers (two for each point), prepare note-cards and short (timed up to 3 minutes) speeches, which are followed by questions from the opposite team. The entire process is moderated by the professor.

Activity 2 (CHI-madness speeches) @ Workshop 2

Following the work on workshop 1, students receive a few additional videos and selected papers and are asked to choose a subject from a subjects-list created by the professor. The selection is based on a simple first-come-first-served selection facilitated by the LMS. Then the students must prepare (as homework) extremely short presentations, based on the CHI madness model (i.e. one or two slides only and a timed speech from 60'' to 90''). These speeches are given on the workshop and are followed by questions and a short discussion moderated by the professor. This one is typically the shortest workshop, lasting just over one hour.

Activity 3 (Creativity design) @ Workshop 3

For the preparation of this activity, the students receive video lectures for interaction design issues and are informed that a short test will be given at the start of the workshop. The test is 10 multiple choice questions with 4 choices each, available on Google forms. Based on students' scores on the test, equally balanced teams (in terms of students' scores on the test) of up to three students are created by the professor and each team is assigned a color (e.g. red team, green team, etc.).

Then, the teams were given a set of cards and a gamified process of design experience starts. The cards are from the Ideation Toolkit for the IoT v0.6 [7]. Some sample cards of each category are shown in Fig. 1. From left to right there is a "mission" card ("Tangibles" in this example), a "things" card ("Office desk"), a "services" card ("Calendar"), a "human action" card ("Location change"), a "feedback" card ("Sound") and a "criteria" card ("Attraction").

The workshop is altered slightly from the original creators' idea, to include some gamified elements, such as card drawing instead of card selection and turn-based contribution for each student, forcing everyone to actively participate in their team and avoiding a student monopolizing the teamwork. Furthermore, each team's result (which in this case is an elevator pitch that could be used for business development) receives a score, based on peer voting after their presentation.

So, in our case, the teams had to draw two "mission" cards, select and keep only one, and then all the discarded "mission" cards were available for a re-draw round, for teams wishing to make another choice. After the teams select their cards and decide on their scenario, they must define their personas and then, in turn, are asked to choose and combine cards of "things", "services", "human actions" and "feedback" related to their scenario. Following, the teams use the "criteria" cards to improve their concepts and prepare an elevator pitch to present their concept to the other teams. Finally, all teams vote for other teams' ideas to create a score for each team. In this gamified version of the workshop, the "criteria" cards were used to provide subjective scores for each criterion. This workshop typically lasts quite longer than most other workshops, reaching (and in some cases even exceeding) the 3 hours.

Activity 4 (Interaction design) @ Workshops 4 to 7

This activity is the longest one and is conducted in four consequent workshops. Before starting the workshops, the students form groups of 3 or 4 persons. Since they are expected to collaborate after workshops, they are free to assign themselves choosing their own teams or using the LMS forum to discuss and organize the teams. During workshop 4, each team is randomly assigned a closed folder which has a single page system's description within. These initial specifications are written by the professor, using plain language and aiming to specify a system without room for misinterpretations on one hand, but being abstract enough to stimulate creativity and alternative designs on the other hand.

Brief outlines of such systems used over the years are: "*A system supporting an anesthesiologist during a surgery that would require as input the drugs and their dosage and it could monitor the patient and report to the anesthesiologist during the operation*", a system inspired from the syringe example from [8] (page 8), or "*A system for elderly people that would serve as information desk at a hospital they visit for a routine check, after reading their social security card, to inform them about the options they have and to schedule appointments*".

Following, the teams are working isolated to discuss their system and define the basic personas. Then, the class is regrouped, and each team presents their system and personas to the class, receiving feedback from the professor and peers. Then, the students separate once again in groups and they design basic mock-up screens and user interactivity, using pen and paper. For these screens, they also receive feedback when the class was once again regrouped. An example of one of such mock-up screens created during workshop 4 for the second system described above is shown in Fig. 2.

Before the next two workshops (which are after the spring break, thus allowing the teams some time to work on their designs) the teams present their personas online and design a rapid prototype (with adequate interactivity) of their system. Fig. 3 shows the same screen as submitted by the team. Workshops 5 and 6 are about role-playing in the HCI laboratory, where the students switch roles: They participate as "users" of other teams' prototypes, based on the scenarios the teams submit or collaborate with the HCI stuff as evaluators.

Figure 3: First design, used on workshop 5 evaluation.

Figure 4: Example of a user's gaze-plot on the first design.

Figure 5: Final design, after workshop 6 results.

Towards this goal students as evaluators are operating eye-tracking [9] and physiological measurements equipment, while the "users" work with their prototypes. For these workshops, the Tobii Studio eye-trackers and the PhysiOBS [10] tool are used.

Following the evaluation sessions, the teams are given the opportunity to redesign their prototype and to improve their design based on the evaluation results. These results include heat-maps, gaze plots and Galvanic Skin Response (GRS) measurements as in [11]. An example of such a user's gaze plot is shown in Fig. 4, where is clear that this user had difficulties to identify the correct action. Finally, during workshop 7, which traditionally is a lengthy one, all student groups had time to present their final system's design and to discuss with the professors and peers the concept, the process and the improvements they made throughout the entire activity. Fig. 5 shows the final design of the same screen used in Fig. 2, Fig. 3 and Fig. 4.

Activity 5 (Inquiry methods) @ Workshop 8

During workshop 8, and after watching the professor's videos related to inquiry usability evaluation methods, the students work as participants of focus groups and as moderators/reporters of the group related to their design. They also work individually on standardized questionnaires such as SUS [12] and its Greek version [13] evaluating designs apart from their own team's system.

Activity 6 (UI design efficiency) @ Workshops 9 and 10

For this activity, the students study videos related to Keystroke Level Model (KLM) [14] and the Fitts law [15]. During workshop 9 they work as a team, investigating improvements on their screens working with pen and paper and discussing alternative designs. Then, workshop 10 takes place in the computer room, where students are using the KLM-FA [16] to evaluate examples from online forms and propose design changes. A pre/post test questionnaire is used in the beginning and end of workshop 10 to evaluate the educational effectiveness of KLM-FA [17].

Activity 7 (CHI-madness speeches) @ Workshop 11

In a similar manner to the second activity, students receive a few additional videos and selected papers and are asked to choose a subject from a subjects-list created by the professor. The subject list for this activity includes state-of-the-art HCI issues that haven't addressed in the previous activities. Then, they prepare (as homework) presentations, which are followed by questions and a short discussion moderated by the professor, just like activity 2.

Activity 8 (Gamified review) @ Workshop 12

The final activity and workshop of the course includes a series of "Kahoot!" games [18] serving as a course review. The workshop 12 concludes with discussions on the course *per se* and students'

suggestions for elements of the course they liked and issues they disliked from their experience in the flipped classroom model, the workshops and the activities.

LESSONS LEARNED

Over the years the course has reached its current form, and although something new is added every year, some important lessons learned that could help HCI educators to introduce similar novelties into their classrooms are outlined hereinafter.

Suitable for courses with limited class hours

This approach is quite similar to a studio-based teaching concept [19]. Ideally, the studio-based approach requires students to have attended background courses. In most undergraduate computer science curricula this is not the case since there is a single HCI course with limited classroom hours. In this case, either the students need to actively search and find learning resources to address their knowledge deficiencies [20], or the course has to combine lectures with studio-based activities. In most cases neither is feasible, due to classroom hours restrictions and since students fail in critical reading of scientific literature when they don't attend lectures. Therefore, this flipped classroom approach is suitable for courses with limited classroom hours, allowing both theoretical knowledge on the field combined with practice.

Involving students from day one

The first introductory lecture is essential for the success of such a course, mostly because many students are not aware of the flipped learning model and they have concerns about the required effort from them, the course organization and the assessment method. Relaxing their concerns and discussing the course organization, the activities and their expected effort is an essential task. Falling to spent time on this task and engaging into the discussion all students might reveal problems later.

A concern when designing this course, was that the effort required by the students might be more than what the typical effort on other courses was. Experience showed that the effort might be a bit more in terms of absolute time, but it was very different in terms of quality time. In fact, based on the experience over the years, it was easy to convince students that their "homework time" will be significantly reduced using this flipped classroom model.

Educating students on how to work in a flipped classroom

"*Watching a video of me solving a problem and expecting to learn, is like watching an aerobics video while sitting on your couch and expecting to lose weight!*", is a funny starting statement often used during the first lecture while discussing how to study the course's educational videos. Improved from years of experience, the current course's videos include frequent reminders such as "*Please press pause and try to solve this…*", followed by "*Now that you have tried your own solution…*".

Professor's short videos

Videos speak the language of modern students. The students appreciate a lot the videos created by their own professor (and not other people's videos, regardless of how famous these people are) and prefer videos that are not edited. In fact, while in the previous years the videos used for this flipped classroom course were edited, the videos used nowadays are not edited. Since they are short, it is better to stop and capture it again when something goes entirely wrong (e.g. a major interruption or something said entirely incorrectly), while leave into the videos issues that one would normally edit, since these are exactly the issues that add authenticity and the "*feel like a lecture*" style. Other people's videos are used only as parallel studying of a topic already discussed in a professor's video. While having flawless videos is not that important, having short videos is extremely important. In this course, most of the videos are kept under 3 minutes and in the few longer ones there is a warning that this video is longer than the usual. The longest video of this course is still under 7 minutes.

Videos are useful in other off-classroom activities as well. For example, during the early years of this course, professor's feedback on homework for sequential activities (e.g. activities 4 and 5) was organized during scheduled meetings in office hours with the student teams. Using a screen capture video, while annotating and discussing a team's design has proven extremely time effective (for both professor and students) as well as an educationally efficient method.

A suitable course for busy students

This course format is appropriate for busy students, as most M.Sc. students today are. Most students of this M.Sc. program work either part-time or full-time. These students could watch the videos anywhere and anytime on their own pace, without need having scheduled homework hours. A student working as a tutor for mathematics for high school students said "*I waste so much time on public transportation going from one student to another. Now I am doing my homework on the bus!*".

Maintaining a casual classroom time

Since most of the workshops were project-based collaborative activities, allowing students to have their coffee and soft drinks on the tables while working, introduced a more relaxed environment. As a student said, "*I felt like working within a team in an employ-friendly company, rather than being in a lecture*". In most cases, removing the formal classroom etiquette has a positive effect on students' enjoyment and perceived satisfaction form the course.

Small secrets related to this casual classroom atmosphere is the use of team colors instead of using student's names (as in early years). Students felt better playing for the "red" or "yellow" team, rather than teams with their names. Balancing teams so to have students from various fields into the same team also aids towards more fun. In fact, balanced teams perform better in most activities since students complementing each other.

Proper tools and workspace

Having own tools and the HCI lab available for the experiments is essential to create the required hands-on experience for the course's activities. Some of the tools used in this course (e.g. KLM-FA, PhysiOBS) have been created as well as to cover this need. Since "Kahoot!" questions format is very restrictive for an HCI course a future goal is to develop a similar tool that allows answers in form of diagrams. An alpha version of this tool (called Diagram•-∘atic) will be used in the next MHCI program.

Although might seem unimportant, a success factor of this method was the availability of an appropriate lecture room that could be switched from a typical presentation room to a team-working environment without many physical difficulties. The room used was the faculty meeting room. This room, on one hand, has a large meeting table that accommodate over 40 members and which was used to have small teams of students working separately and with satisfactory isolation. On the other hand, it has a small audience space with 30 chairs and a podium with presentation facilities (e.g. a computer and a data projector) where students can move fast to watch a peer presentation. Most of the activities discussed in this paper are better accommodated in such a suitable room.

Administrating activities and assessment of students

Monitoring student's attendance and organizing things for students that missed a workshop is not an easy task to do, especially in workshops that run in a sequence. When a student failed to attend a workshop, extra effort is required from both the professor and their peers to include them back in. This course would not work in cases when student attendance is elective, since, even as it is, allowing students to miss up to two lectures is causing a lot of organizational problems.

Another difficult task the professor must accomplish is assessing an individual student's performance during collaborative activities. In most cases the professor needs to keep track of various individual student's data, while moderate the activity, organizing things, explaining the process and answering questions. In the workshops that take place in the HCI laboratory, such things are easier, since there are assistants in the lab, but during activities such as the IoT game this is a very challenging task to accomplish.

Students' satisfaction

The most controversial activity in terms of student's satisfaction is the gamified creativity design using the Internet of Things (IoT) cards. Most students liked this activity and considered it as "*by far the funniest activity of the course*", while others (mostly from a computer engineering background) preferred "*more practical activities, like the ones we actually design the user interface and not playing with cards*". Some other negative comments over the years, included that the course didn't

go very deep into technical work (one student commented "*debates and working with cards are great but I am a computer engineer so I must write code*") and that it wasn't as "*easy course*" as other courses of the same M.Sc. program are.

Using various tools: a) the formal anonymous university assessment system, b) the discussion at the last workshop, c) a questionnaire with open questions used at graduates (approximately one year after graduation), it is measured that this course has a very high student's satisfaction level. It has one of the highest scores in the formal university assessment and students express their enthusiasm for the novel methods used, constantly over the years.

CONCLUSION

To conclude, teaching HCI in a way that will engage students into various hands-on activities is a challenging task. A flipped classroom model, adopting a workshop structure, including collaborative project-based learning techniques and activities, is probably a step toward the right direction. As these experiences and lessons learned indicate, there are many elements which could affect each course's success, but a motivated professor could overcome difficulties and deliver a course that their students will find both educational and pleasant.

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