LiveClassroom

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Resumo

Apesar dos desenvolvimentos tecnológicos na educação, a participação e envolvimento dos alunos nas salas de aula ainda precisa de melhorias substanciais. Na verdade, muitos estudantes ainda têm dificuldade em participar ativamente e fazer perguntas que, por vezes, podem interromper o fluxo da classe. LiveClassroom fornece aos alunos meios para melhorar a sua interação com instrutores durante uma aula, por exemplo, fazendo perguntas, apresentar feedback do curso ou da aula e respondendo a perguntas do instrutor on-line para fins de avaliação. Além disso, aumenta a aprendizagem dos alunos e as interações em comparação com estudantes que não usaram LiveClassroom.

Keywords: blended learning, backchannel, participação, envolvimento, feedback, presença.

Abstract

Despite technological developments in education, in-class student participation and engagement have yet to see substantial improvements. Indeed, many students still have a hard time in actively participating and asking questions that can sometimes disrupt the flow of the class. LiveClassroom provides students with means to improve their in-class interaction with Instructors, eg. asking questions, submitting course or lecture feedback and answering online instructor questions for assessment purposes. Additionally, it increases student learning and interactions compared to students who did not use LiveClassroom.

Keywords: blended learning, backchannel, participation, engagement, feedback, attendance.

Table of Contents

List of Figures

List of Tables

1 Introduction

Recent years have witnessed substantial technological advances in e-learning tools and educational multimedia content dissemination through the Internet. However, many problems still remain in technology enhanced learning. While richer content is being provided, student participation and engagement have not seen similar development. Since students can review class topics at a later date they might feel a disconnect towards the class, because the prospect of asking a question in front of others or be mistaken is daunting for some, so they stay quiet and tell themselves they will look at it later. However, this is not ideal, as instructor-student dialogue during a lecture can greatly improve learning outcomes [Roc10] and it needs to be improved with technology. Because, although technology is already part of the classroom, it is mostly used by students for distraction purposes. E-learning has tried to remove this disconnect by embracing it, changing the pedagogy paradigm with distance learning. In this way students do not convene in a classroom with an instructor, but learn at their own pace and time, wherever they want, from the contents that instructors makes available for them online. Blended learning tries to bridge the gap between e-learning and conventional learning approaches by making use of online forums with most of the lecture content and allowing the students to share their ideas and doubts with themselves or with the instructors, while still having regular face to face classes.

E-learning and blended learning focus on aspects that are outside of the classroom. While technology provides ways to improve learning during off-time, it is during a lecture that students develop critical thinking, become motivated and stay engaged by asking questions and interacting with others [Roc10]. Students worry about displaying a positive image of themselves to their class mates. This can prevent their participating in class due to evaluation anxiety. Many fear being judged by others because they made a mistake or just do not want to be the focus of attention [Roc10]. Additionally, posing a question can interrupt the flow of class. Even if students feel more comfortable sending an email to the instructor, they will need to wait for the instructor to have time available and they might not get the best response possible due to the limitations of the medium.

1.1 Objectives

I developed a tool-set to support bidirectional communication and evaluation to promote student engagement in lectures, improve teaching in blended learning settings while increasing student participation in simple and unobtrusive ways.

This approach, which I call LiveClassroom, draws inspiration from recent related work and is available to a multitude of devices and operating systems, allowing students to interact with the class towards improving their engagement and participation. Among other functionalities, students are able to pose questions and ask the lecturer to repeat subject matter that was not clearly understood. Anonymity allows shy or socially challenged students to participate and improve their learning, while maintaining a log of whoever interacts with LiveClassroom, with the intent of minimizing "anti-social behaviour" or attention-hogging by overly active students. The instructor has immediate access to these questions and can weave them into the current explanation or answer them when that would have the least impact

on class flow. LiveClassroom is simple, unobtrusive and easy to use to minimize distractions and keeps track of student attendance. Lastly, the instructor is able to quiz students on topics previously discussed at any time during class, not only for grading purposes but to keep the class on their toes and engaged during each lecture.

LiveClassroom's user tests have shown an increase in student interactions of 20% and a higher test score of 13%. Though it needs more testing and analysis in a realistic environment to determine if this projection can be maintained.

This thesis is organized as follows. In Section 2 there will be a review of relevant research on student engagement, backchannel usage in the classroom, microblogging for educational purposes, multitasking and distractions during a lecture and Blended learning and gamification in higher education courses. Followed by the final prototype explanation and it's evolution in section 3. Ending with the results obtained and their discussion, section 4

2 Related Work

In this section various research papers that are similar or related to LiveClassroom will be resumed, Advantages and disadvantages will be analyzed as well as the results gathered from each research, forming the basis for the creation of LiveClassroom. The Following topics will be:

Student Engagement which is the main motivator for student learning. Backchannels are the core of this paper and what LiveClassroom will base itself on. Microblog's limited text length and social network aspects could benefit student interactions. Multitasking for Distractions is a definite problems in the classroom due to the prevalence of personal Internet connected devices. Finally, Blended Learning & Gamification offer other ways to improve engagement which is a core feature that LiveClassroom will approach.

2.1 Student Engagement

Engagement is very important when learning something new, if you are not interested in something it is less likely that you will care or pay attention, but it is also a very complex cognitive function and difficult to define. Engagement is more than classroom behaviour or presence, it is about having a relationship with learning, it comes from participating in discussions and doing course related work [LS09]. Here, I will focus on behavioural engagement, which is the subject LiveClassroom will tackle. Behavioural engagement includes attending classes, arriving on time, collaboration and communication with the instructor and other students, meaning that the student is physically ready and willing to learn.

If a student is not engaged and not participating it becomes extremely difficult for instructors to help, even during the lecture, if they do not know what the students are not understanding then he can not help them. Furthermore, this provides valuable feedback for future iterations of the course, if there is a recurring point where students do not understand something it will make the instructor adapt, whether it being adapting their discourse or changing the class slides to be clearer. So more than just the students learning being hamstrung, the instructors ability to correct the problem is also debilitated.

Engagement improves a myriad of desirable traits such as cognitive development, practical competence and social skills but most importantly, improved grades [TP10]. The value of engagement is unquestionable and it is the responsibility of instructors and institutions to promote it because it benefits all students.

Can this behavioural engagement be measured? Yes, but usually it is done by measuring disengagement. When students are late, do not show up, are aggressive or negative or simply do not interact in the classroom they are disengaged and thus less likely to learn or to desire to learn. Well-know annual surveys, from NSSE to UES and SES gather student engagement feedback, in North America, Australia and United Kingdom, on a 4 point Likert scale but lack qualitative data [SBMK15]. These surveys show that Computer Sciences students perform below average on almost all areas of engagement. This means while there is a problem there is also fertile ground for innovation.

Some changes to promote engagement have already been made, such as giving credits to students who participate, answer correctly or attend classes. While these provide incentive they do not provide

the means to engagement, there needs to be a way to facilitate student interactions with the instructor to better their learning. Can technological usage in a classroom have a relationship towards student engagement? Yes, students who engage in course-related technology are more engaged in the course when compared to other ways [CLG10]. This positive correlation between technology and engagement should be explored to determine its precise nature.

Since most higher education students have some kind of personal device that has Internet access, implementations of technological solutions are easier. Like quiz-based tools [MMP+14] that not only promote engagement and participation through anonymity but also collaboration and feedback towards the instructor. This allows the instructor to analyze the weak points of the lecture by looking at the ratio of correctly to incorrectly answered questions related to a certain lecture topic, improving the course for future iterations.

This technological use in the classroom seems to revolve around backchannels that facilitate instructor student interactions.

2.2 Backchannels

Backchannel defines a secondary channel of communication between the speaker and the listeners, giving listeners the opportunity to interact with the speakers in unobtrusive ways. Listeners usually transmit this information using body language, nodding their heads when they do not understand something for example. This gives the speakers the possibility to adapt their lecture based on this information, however not all listeners are comfortable in doing these public demonstrations, or will agree just so they are not asked any questions and not have to speak up in class. Also, in big classrooms with many students it is hard for the speaker to pick up all the signals listeners make.

Yardi [Yar06] implemented a public backchannel system at the University of California at Berkeley's School of Information for a year, under the assumption that students can learn more with a peer to peer system. With the belief that students are active, continuously search and try to build their knowledge of a subject through collaboration, using their previous knowledge as a basis to make sense of new information. Yardi defends that this type of chat room enhances collaboration by allowing the students to actively learn in a positive way, with other peers, through exploratory discussion based on question answering and finding a consensus. This type of discussion can fail if the ideas are accepted without challenge or critical thinking but since this is a higher education environment, the behaviour in question was not apparent. In Yardi's system, students create their own knowledge by guiding the discussion to topics relevant to themselves, translating in a more active and organic learning experience, but it can also provide distractions for the students as they try to pay attention to several vectors of information at the same time, processing information in an evermore superficial way. This topic of multi-tasking is a subject of some debate as some studies believe that students are capable of doing it [KZ05] while others reject this idea [HG03]. Yardi leaves some guidelines that are emerging, stating that backchannels offer social and educational benefits for teaching pedagogies, that they enable instructor self-assessment by allowing the instructor to review the chat room log and that it should encourage collaborative learning.

McCarthy et al. [MB05] implemented a similar chat room system during the CSCW2004 Conference, with about 450 participants during the course of 4 days, giving similar results as to those of Yardi. Some participants referenced that it was difficult for them to pay attention to the presentations as well as the chat room at the same time. The trial showed that it is possible to make use of collaboration to improve the context of these presentations and to provide tangential learning opportunities. From the speakers side of things, they noted some disheartening feelings by watching so many people interacting with their devices, not being able to pick up on the body language from the audience to adapt their presentation, nor being able to perceive if people were interacting with the backchannel or just simply distracted and not paying any attention.

Classcommons also shows a public backchannel system [DRCG09,DRC12], used during a semester with 100 students divided into 2 classes. It differs from the previous backchannels with the inclusion of the instructor and the fact that students could use pseudonyms, the chat room was continuously being shown in a separate projector to the one used to show the class slides, it was clearly visible by both instructors and students. This chat room permitted text messages, images and also YouTube videos to be sent and shared between the students. These messages where shown in real time, allowing the students to continue the discussions and vote for the messages they considered important, but also allowed the instructor to keep an eye on what was being discussed and intervene if necessary. An important factor in this study is the use of pseudonyms, with the policy of Public Anonymity and Private Accountability (PAPA), students could use their real names or pseudonyms created by themselves to send a message, and while other students would be none the wiser of who was sending the message, the instructor could always find out who was who after class. This policy allowed students who were not as comfortable in exposing themselves to feel safer with the use of anonymity, promoting interaction, all the while reducing its bad use. Results show that the students felt that ClassCommons did not distract them from the class, that pseudonym use was large and that students unanimously enjoyed the system and would like to use them in other courses. Students particularly liked the fact that they could ask questions and get answers quickly, whether it be by other students or by the instructor. They liked the collaborative learning component but felt that the use of pseudonyms allowed for the posting of irrelevant and distracting information.

Another study with backchannels, this time completely anonymous, with limited types of interaction, the Fragmented Social Mirror [BK10] was implemented on a class with over 100 students in higher education. These students could ask anonymous questions, participate in the discussion with more information, agree or disagree with an instructor question and ask to repeat the last portion of the class. Students would make these action through their own personal, Internet ready devices which was then showed in a separate projector to the one used to show the lecture's slides. These projectors were clearly visible by everyone to enable the instructor to answer any question posted. Two important nuances in this system are the fact that the student, after interacting with the system, could not interact again for the following 10 seconds, this was used to discourage excessive socialization, and the fact that questions would only be visible on the projector for 1 minute, so the instructor would have an easier time keeping up with only the recent questions and not get confused with all the others he had already answered.

Results from this study show that simplicity of design is an important factor, as well as the possibility to easily read and incorporate the answers into the explanation the instructor is finishing, but on the other hand, anonymity brought some issues with keeping order and maintaining the discussion on topic.

Nelimarkka et al.[NKL+14] also demonstrated some similar results with his 1 month test. A completely anonymous backchannel, this time with a younger demographic, 22 students with 12 or 13 years old. This study allowed students to comment and respond to commentary from their colleagues through their personal devices, these conversations were publicly shown to the students and the instructor. Again this study shows that the students value anonymity, as it provides an added layer of security when trying to express their opinions or doubts giving more freedom of expression, because they know that most negative consequences they fear will happen can be avoided, allowing the student to interact more with the class, resulting in better learning and engagement [DW07], but, even though there were some non-relevant conversations to the lecture's topic there was no anti-social or negative behaviour with other students.

One final study by Mathiasen [Mat15], with a small number of students, 20 to 43, only has a multiple answer approach, where the instructor would poll the students, at various times during a class, giving them a question with various alternatives of response. The student's feedback on this study is that it does provides value, they felt that there should be more than just choosing what they think is the correct answer there should be a discussion, and more importantly, it should immediately follow the question so as to not forget the subject matter or the arguments. Time is a key concept, the voting session should not interrupt the flow of class by taking too long nor should it be too short as to not provide the students enough time to reflect on their answer. Finally they pointed out that it is not the instructor they are afraid of being embarrassed in front of, it is the rest of their colleagues, so there should be a system where they are shielded from being pointed out by the other students but still able to be followed by the instructor.

In short, backchannels do in fact increase participation and interactions from the students with each other and to the instructor, the usage of anonymity can further increase this and allow more people types of students to participate, but can be misused, with distractive anti-social behaviour, in some cases it can increase 90% [KH05]. Allowing for collaborative learning can improve the way students learn without impacting the flow of class but can easily distract student with sensory overflow by focusing on 2 things at the same time.

Systems with high amounts of expression like [Gol05,Yar06,MB05,DRC12] increase communication capabilities but require more attention while systems with low amounts of expression like [Mat15,BK10], [NKL+14] limit student communication but guarantee that it can be interpreted quickly.

2.3 Microblogging

The previous section refers to the use of backchannels implemented and created by their respective authors, what happens when known commercial microblogging implementations are used as backchannels? Microblogging consists of short text messages, with fewer than 200 characters, usually working as a social network tool.

Microblogging allows for real-time interactions between users of different technologies and devices, which is what is needed for LiveClassroom, where the class shows this kind of device diversity. Each student would create a new account or use an existing one and a hash-tag would be created so that all the information related to the class would be grouped there for easy access.

Twitter as an education tool has the potential to make a more dynamic class [GH08], this Romanian study, using a tool very similar to twitter, found that its use in a classroom can induce a sense of community by promoting collaboration between students and enabling them to express their opinions and doubts in a space created for this purpose. This way the students are always connected to each other and to the instructor, making it easier to disperse useful information. The fact that students are limited to only a few characters incites them to summarize better and get straight to the point. On the other hand there is the possibility of a question being lost in the multitude of responses and can also distract students from the lecture as they, through twitter, can easily start talking with their friend or receiving news from things unrelated to the topic of the class. More importantly if microblogging is used with a very large class, and is used frequently it can be hard for the instructor to keep up with the amount of information with their limited time.

A more complete and thorough study by Cetintas [CSA+11] tried to remedy this by trying to sort though each message and catalog it as relevant and irrelevant. Their research, spanning a semester with 243 students in higher education, used a private microblogging tool, similar to twitter but specialized for the classroom, with this tool they could post questions anonymously and vote on questions to give them more relevance. Though their final results are somewhat irrelevant to this paper, since there is no plan to incorporate a message sorter of any kind, it is interesting to note that they corroborate the backchannels findings, in that anonymity did bring irrelevant questions into play with some of them getting voted by other students. Each student having a mean value of 5.5 relevant questions to 2.2 irrelevant questions.

Menkhoff et al.[MCB+15] usage of twitter showed very promising results on two classes with 45 students each. Students would send their comments, questions and views during class through twitter, these were then projected on a screen, separate to the one used by the instructor, in real time so that everyone could see everything that was happening with the class created hash-tag. The instructor was then able to accompany the messages and periodically pause the lecture to address them. This system makes use of blended learning to incite positive contextual learning to the lecture's topic, collaboration between students is enabled due to the social networking nature of twitter. It appeals to a newer generation of students driving them to pose their questions. The students valued twitter as a means of communication stating that it helps participation and interaction and would like to see it used in other courses, though they noted that it can be difficult to keep track of tweeting and paying attention to class [OK12] and that the instructor's tweets should be highlighted and visible to enhance communication and learning effectiveness.

With this research it can be gathered that microblogging did not differ much from the backchannel findings, it allows students the freedom to make questions more freely during class and the limited message size does make information easier to process but again the use of anonymity does make negative and distracting comments a reality and also adds to the sensory overload of the students,

having to divide their attention. In the end the only real difference is that twitter would be available to the students at all times, not just during class, so they can review questions and views that were expressed in the class easily, when they want.

2.4 Multitasking for Distractions

The previous subsections mention that students feel that backchannels and microblogging during class can affect their attention to the lecture due to fact that multitasking is a demanding feat. Not only this but the ubiquitous use of computers facilitates distraction with social networking sites and email. How big of an impact does this really have?

Fulton et al. [FSSB11] set out to demonstrate the impact of multitasking in the classroom, they set up an in-class activity where, during a typical lecture with PowerPoint slides, students were divided into 3 groups, one group was not permitted to use any computers, another group had to have their email open and the last group had their email and facebook open. During class, distractions were set up for these last 2 groups, emails were sent that require a little of Internet research to answer, and facebook surveys were also sent. At the end of class a small quiz was given to the students to answer and assess how much of the lecture they had learned. It is of no surprise that the no distraction group (59.4) did better on average that the single distraction group (38.5) and the dual distraction group (25.8). Students noted that when shown these results they were somewhat enthused to make some changes to their online use during class, but it seems unlikely that they would ever stop using their computers as they multitask to make better use of their time.

A broader study by Sana et al. analyzes the effect of computer distractions on others that are in view of it [SWC13]. This study consisted of 2 experiments, Experiment 1 dealt with the impact of multitasking by a computer user in class. 44 higher education students participated on a typical lecture and were asked to take notes on their laptops, while occasionally they were asked to complete an online assignment not related to the lecture. Experiment 2 focused on the effect that a multitasking user has on a person in direct view of their laptop, a new class with 39 higher education students were again part of a typical lecture, some where seated in specific places with a view of a multitasking classmate, while others had none of these classmates in sight. Both experiments were followed by an exam to test the students knowledge of that lectures topic. Experiment 1 showed an 11% lower score for the multitasking students, as listening to the lecture, taking notes and doing online tasks translates to a sensory overflow due to limited attentional resources. Students in this experiment were aware that multitasking would hinder their learning. Experiment 2 showed a 17% lower score for students that were taking notes while in view of a multitasking student, meaning that students from experiment 2 were placed in a disadvantage due to others decisions. These students estimated that their learning would be barely hindered by their peers computers, but the results show that was not true It seems that the multitaskers are able to time their activities in a way to reduce distractions while the ones watching are trapped into looking more often. Multitasking is a juggling act, the important action can only be performed if the secondary actions are simple or automatic to do and asynchronous to the important one, but even in this case it still had a negative learning impact.

What are the causes for students to multitask and distract themselves from the lecture? Taneja et al. [TFF15] attributes it to several factors. The fact that students have a positive view on the use of Internet and other technologies, plus the fact that they can easily indulge in these practices during class leads to distraction. The occurrence of distracting actions around a student by others can also influence them negatively. If a student finds the lecture difficult to grasp, is not paying attention or is disinterested will lead to online escapism, meaning that class engagement is very important to counteract this. Creative approaches to the class that add fun and reduce student apathy increases attention and engagement. Fried [Fri08] also corroborates this. The more a student uses a laptop the lower their class performance, the lower their attention and understanding of the lecture.

Laptops when used only for note taking in class have a positive influence on learning, but demand more cognitive resources from the user by enabling distractions. When do these costs outweigh the benefits? These studies show that unstructured use of computers and multitasking and distractions are a real problem, so, could it be feasible that occupying the students screen with something related to the lecture and support their interaction with the instructor yield better results?

2.5 Blended Learning & Gamification

Blended Learning consists on the combination of a technologically mediated learning environment with a face-to-face learning environment [Gra06], blending them together into one course that contains the best of both worlds by featuring an improved teaching method that focuses on being interactive rather than transmissive, and promotes collaborative learning among students. The Fénix system, a framework that students of Instituto Superior Técnico use,already promotes a type of blended learning, an enhancing blend that permits student access to the class slides and other related information to the course. The Multimedia Content Production course increments on this by adding gamification, a process that integrates game elements into a gameless object to add gameful characteristics [YPW14]. This process has shown tremendous potential and benefits to this course specifically [BGJG13], showing an increase in lecture slides and related information downloads, student participation in the forums, lecture engagement and ultimately final grades. Common gaming elements introduced are experience points (XP), leaderboards, badges and challenges. In gamified courses, students start with the lowest grade, and strive to increase it by earning XP, which can be done by completing instructor appointed challenges related to course topics, or earning badges. Badges are smaller rewards that can by earned by completing minor tasks, like downloading all lecture slides or contributing to the course forums. Typically, students are ranked by their XP in a leaderboard type site, where students can track their progress.

Another analogous gamification study by Kim [Kim14] used gamification on her course with the intent to immerse the students into the concepts of game-based learning using Google+, a social network site, to share and gather ideas. Students would earn experience points (credits) by completing everyday activities while still having face to face sessions to articulate and develop their learning. There was a leaderboard that ranked all the students by credits earned with their avatars for anonymity. Kim claims that a strong connection between the course pedagogy an its content enhances learning and student engagement.

What demonstrative effects can blended learning alone have on other courses? This study [Kiv14] shows an increase in final grades and overall course performance, in a class of 66 higher education students, by adapting their approach to traditional learning. By pre-recording and pre-planning their content and posting it online students were able to review this content before class, which was entirely devoted to active learning to clarify points and cement the online lectures. This approach allowed students to view the content at their own pace, rewinding when needed and reflecting on the information given without pressure. While this study does not directly similar to the Multimedia Content Production course, it shows that a small difference in the teaching style can have an impact on the outcomes of the students.

What about gamification effects? Ibanez et al. [IDSDK14] introduced gamification into their course with the additions of a leader board area, where the students were ranked based on their current course score, and a badge showcase area marking each students achievements. This course, comprised of 22 students in higher education, revealed that most students kept working even after getting the maximum grade citing that they wanted to get all the badges and desire to learn more of the course content. The researches called the study a success claiming a higher student final grade.

So what defines a "good" blend? or a "good" use of gamification? Course announcements, instructor interaction, class slide availability, grading procedures, making these components available will provide structure and keep learners focused on the course tasks. It is important to guide the students, in the beginning, with clear instructions on what is expected of them, giving examples of completed assignments. Tasks should be varied, coherent, and related to the course content enhancing student learning and immersion. Interaction is very valuable, it should be facilitated by forums, chats, having frequent interaction with other students promotes collaboration.Instructor student feedback is key, close monitoring and immediate feedback impacts student performance [Lis14]. Ultimately students that are engaged and attracted to their work persist despite challenges and obstacles [DHM04,FZ15].

2.6 Multimedia Content Production

Now I will introduce the Multimedia Content Production Course, where LiveClassroom will be included, to provide proper context on how everything will work together.

Multimedia Content Production (MCP) is a course that features a blended learning and gamification approach in Instituto Superior Técnico (IST) university. It features regular face-to-face theoretical lectures, where students gather to hear the instructors exposition, and practical classes, where students are given a task to complete each week, related to the theoretical content that was presented. This course differs from others with the inclusion of Moodle (Modular Object-Oriented Dynamic Learning Environment) which is a free open-source learning management system or e-Learning platform. Moodle is used extensively in this course, it serves as a forum for students to pose questions, that can be answered by either other students or instructors. To log in to Moodle, students need to use their personal university credentials. During a theoretical lesson the first student who correctly responds to an instructor question, receives a code that he can enter into Moodle to earn credits. After each theoretical lesson, instructors create a forum post where students can post related or tangential information they found in order to score some credits. Also, once per week during a theoretical lesson, students undergo a graded

test, with contents from the previous week. To complete this test students need to connect to Moodle through a personal Internet ready device, like a laptop or a mobile. Furthermore, students are ranked in a leaderboard style site according to their credits.

This gamification approach has proved remarkably successful for this course in terms of participation and attendance [BGJG,BGJG15], but have no evidence that their marks were significantly affected by the game-like experience.

As stated above, students need a personal device to complete their lesson tests and the course already provides extensive ways for interactions outside of the classroom but none for inside the classroom.

2.7 Main Issues to Ponder

Now that all the research has been analyzed it is possible to gather the important information that will form the basis of LiveClassroom.

The evermore prevalent use of personal devices with Internet access in education help as much as they hinder students by providing more opportunities to distract them from subjects being taught. This is an important issue because student education is being compromised and debilitated. The objective of the classroom is to provide the student a better learning environment. This cannot happen if students are not engaged, or are not comfortable in the classroom or are unable to interact with the instructor to quell any doubts they have on the lecture. Engagement benefits students in a number of ways, beyond achieving better grades. Course related technology used in the classroom can work towards promoting engagement with the use of backchannels.

From the backchannel research it can be gathered that its implementation benefits student learning by allowing more ways of interacting with the class. Anonymity increases this potential but offers the chance for negative, anti-social comments to emerge. None of these studies mention assessment of each comment. This is a key element and it can suppress most undesirable behaviours if students know they will be evaluated during class. Although having a chat room that is parallel to the class shows that it can promote collaborative learning, multitasking would then become a problem, and provide a means for students to distract themselves and others, which is not a desirable trait. This results in a lower collaboration, but students will still be able to learn from each others questions.

MicroBlogging has some uses in education, allowing for all class interactions to be grouped with the use of hash-tags, helping students to search for information easily. Also, it's limited text length promotes objective writing that focuses on the essential, allowing for a quick and clear read. The social network nature would promote collaboration by students answering each others questions and allowing them to continue interaction even after class. While some Microblogging features would be desirable, the same social network nature would also distract the students, as they can subscribe to other people or companies, receiving news and information from other sources that are not in any way related to the lecture.

The use of a personal device in class is a requirement for the course of MCP, as the course tests are done at the end of specific classes through the use of Moodle. Meaning that distractions are always

available, so the creation of something that can simultaneously occupy their screens and be related to the course is definitely a benefit, but at the same time, be simplistic and easy to use as to not occupy too many student cognitive functions.

Blended learning and gamification are really interesting concepts, and are already implemented in the MCP course, but they frequently talk about an off school option, a forum, a website. The lack of an in class approach is a gap in the system, that should be explored and taken advantage of. If correctly blended and integrated with the class a live feedback system can support students and instructors allowing more freedom leading to a better end result for the course.

Coupled with the above text, these are the most important traits that LiveClassroom approached.

- Promote engagement, a vital component of learning, by keeping students actively participating and paying attention.
- Promote participation, which develops critical thinking and makes students interested, actively thinking about what they are learning.
- Provide anonymity, this extra layer of security will help student who are not comfortable with public interactions.
- Allow in-class quizzing in a fair way, where each student can earn credits by answering correctly.
- Easy interpretation of interactions, for quick and clear understanding of what is written.
- Low multitasking impact by not occupying too many cognitive faculties and minimizing distractions.
- Promote blended learning by providing an accessible, intuitive solution for in-class student instructor interactions.

How do the approaches covered in the related works section match up to these traits? Firstly, how did they analyse participation and engagement? Yardi's chat room approach used an overly simplistic method, using software visualization tools they plotted their chat statistics to look at trends in adoption and usage. With over 400 postings per day, Yardi indicates a general increase in user participation, suggesting that students become more engaged in the chat room community over time, but also states that a hand full of students participated most often. McCarthy's similar chat room approach also shows a power law distribution, with only a small number of individuals having the largest contributions. Through interviews they noted that there was an increase in participation and that the chat room provided value, though there were some who did not participate and only wanted to know what was being said. ClassCommons had more thorough measures, with pre-surveys, mid-surveys and post-surveys, combined with interviews and informal observations. They started by measuring how comfortable each student was with public speaking, as they wanted to see if these students would get somewhat over this fear and participate more. And it proved successful, students participated more often and were interested in using it in future classes. Fragmented Social Mirror sent a pre-survey before implementing the backchannel, to gauge students comfort level when asking questions, which was very little. And through initial observations it was noted that there was little to no interactions whatsoever. After statistical analysis of the backchannel usage and surveys after class, participation had increased significantly and the instructor was delighted with this result, and the students also noted it's benefits and ease of use. Nelimarkka,

through message analysis, interviews and surveys, highlights the importance of anonymity from the perspective of the students allowing for a safer environment and beneficial to learning. There is also an increase in participation and shows the same power law distribution previously discussed. Mathiasen drives the point that digital quizzing during a lecture are considered valuable additions by both students and instructors. Through in class observations, there was a 75% to 100% of responses, but only around 25% expressed their answers further, and even fewer asked any further questions. This indicates that this approach was too focused on quizzes only, and could include a broader backchannel usage. Then Mathiasen turned to group interviews, for a more free form discussion with students. Twitter, from the approaches discussed in the microblogging section, mimicked backchannels a great deal with its advantages being its already widespread use, ease of interpretation and handling. It's only drawback is the fact that there are multiple avenues of distractions easily available.

Table 1. Related approaches compared with LiveClassroom desired traits

Solution	Engagement & Participation	Anonymity	Quizzing	Ease of Interpretation	Multitasking Impact
Yardi	High	None	None	Moderate	High
McCarthy	Moderate	None	None	Moderate	High
ClassCommons	Moderate	Moderate	None	Low	High
Fragmented Social Mirror	High	High	None	Moderate	High
Nelimarkka	High	High	None	High	Moderate
Mathiasen	Low	None	High	High	Low
Twitter	Moderate	Moderate	None	High	Moderate

Most approaches provide high engagement and participation, which was their desired effect, with only ClassCommons and twitter scoring lower because they allow for images, and videos which can distract students more easily. This also causes a higher multitasking impact, mostly due to chat room approaches, that allow for multiple, simultaneous discussions along with the lecture exposition. Nelimarkka has a moderate impact due to it being text based with defined types of interactions, making it a more standardized backchannel. Twitter while providing many types of multimedia from many different sources, the small text length allows for a quick read and smaller bursts of distractions. Chat room approaches are harder to interpret, due to variable and simultaneous conversations, ClassCommons is even harder due to the different forms of multimedia it supports. Twitter and Nelimarkka score higher due to smaller text length and standardized types of interaction respectfully. Most approaches provided either full anonymity (high) or none at all, only ClassCommons and Twitter offer the option of using a pseudonym or not. Mathiasen was a quiz only approach, and so it scores a low Multitasking impact and engagement & participation due to it only being available for limited and short periods of time, and not providing anymore value other than the students knowing they will be quizzed and should pay attention in class. However, it is easy to interpret due to the standardized forms of questions available.

Looking at all these approaches, it seems that a chat room approach is not ideal, especially if the instructor has no visual control over it like in Yardi's. Chat rooms provide too many discussions, and are more propitious to distractions and off topic discussions. Clearly the Fragmented Social Mirror is a more correct approach by leading the students to an instructor student dialogue instead of a chat room free discussion. Limiting a students actions to only a small portion of text will allow for easier interpretation and focused writing, rather than allowing video or images that are more heavy on cognitive functions. Mathiasen's approach did its proposed job in a very successful way, but could be more inclusive with more ways of student interactions. Anonymity, if used correctly, provides an extra layer of security that most students will take advantage of to suppress their social phobias and better their learning. This however, will also bring about the probability of off-topic discussions, but with the implementation of Classcommons Public Anonymity Private Accountability Policy these discussions can me mitigated, with the added feature that the instructor will be able to know who said what at any time. Microblogging has the advantage of small and concise text, which would help the instructor with interpretation. But if a social network, like Twitter, is used it would only provide more avenues of distractions due to all the other non class related content available.

In short, there is no solution that approaches all of LiveClassroom's proposed traits simultaneously, so, in the following section I will explain my own approach.

3 LiveClassroom

Now, with all the research made and goals set up, I will explain the final prototype and how it measures to the main issues above, an explanation on the database structure and the evolution through its various stages.

LiveClassroom is specifically tailored to the needs and conditions of Instituto Superior Tecnico and the Multimedia Content Production course but it is technologically neutral. LiveClassroom is a responsive website that works on mobiles, tablets or any other device. It is stored on the university servers, along with it's specific mysql database. If one would want to replicate this approach, one would need only these components. I recommend Xampp as it provides these features in an easy to install way.

3.1 Student Side

First I will explain the student side, starting with the token acquisition process. When the class starts, the instructor will enable a private ad-hoc network, that the students will need to connect to. Then they must input the instructors IP address into an Internet browser, this will redirect them to a token acquisition site. Alternatively, a QR code can also be shown to the students to accelerate the process if they have a smartphone that can read them. Here, after logging-in with their Fénix ID they will receive an access token. With this access token, they will then leave the instructors network and rejoin Eduroam to access LiveClassroom. This token is only viable for the duration of the lesson. The process to obtain a token guarantees that only students who are in the classroom or in its immediate vicinity can get it, adding to LiveClassroom's reliability.

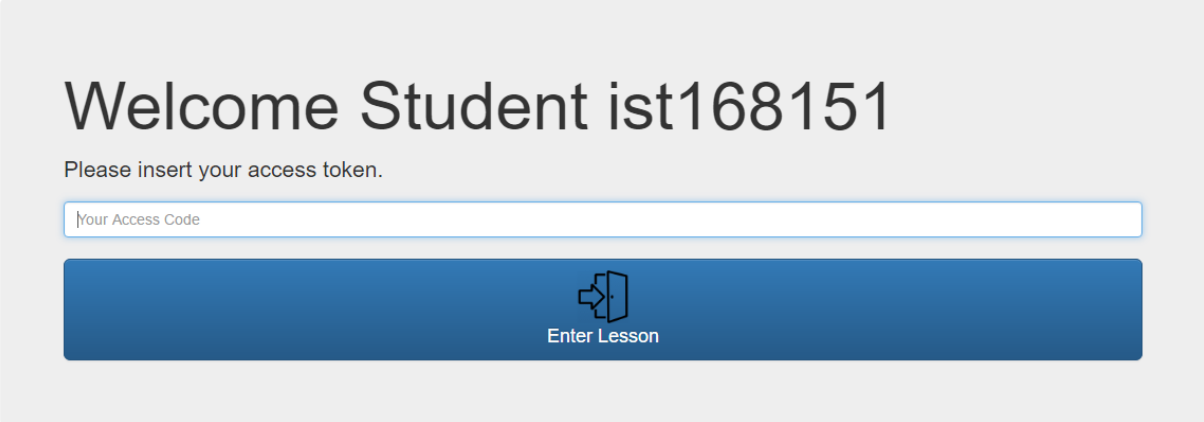

Fig. 1. Student Login

With a valid token they are redirected to an active lesson, where they will have their attendance counted and be allowed access to instructor-student bidirectional interactions.

Figure 2 shows the main student functions of the application, it has the most important interactions at the top. The "I Do Not Understand" button sends the same text to the instructors, advising them to repeat the last section of the lesson. "Submit question" button allows the students to specify what they want to

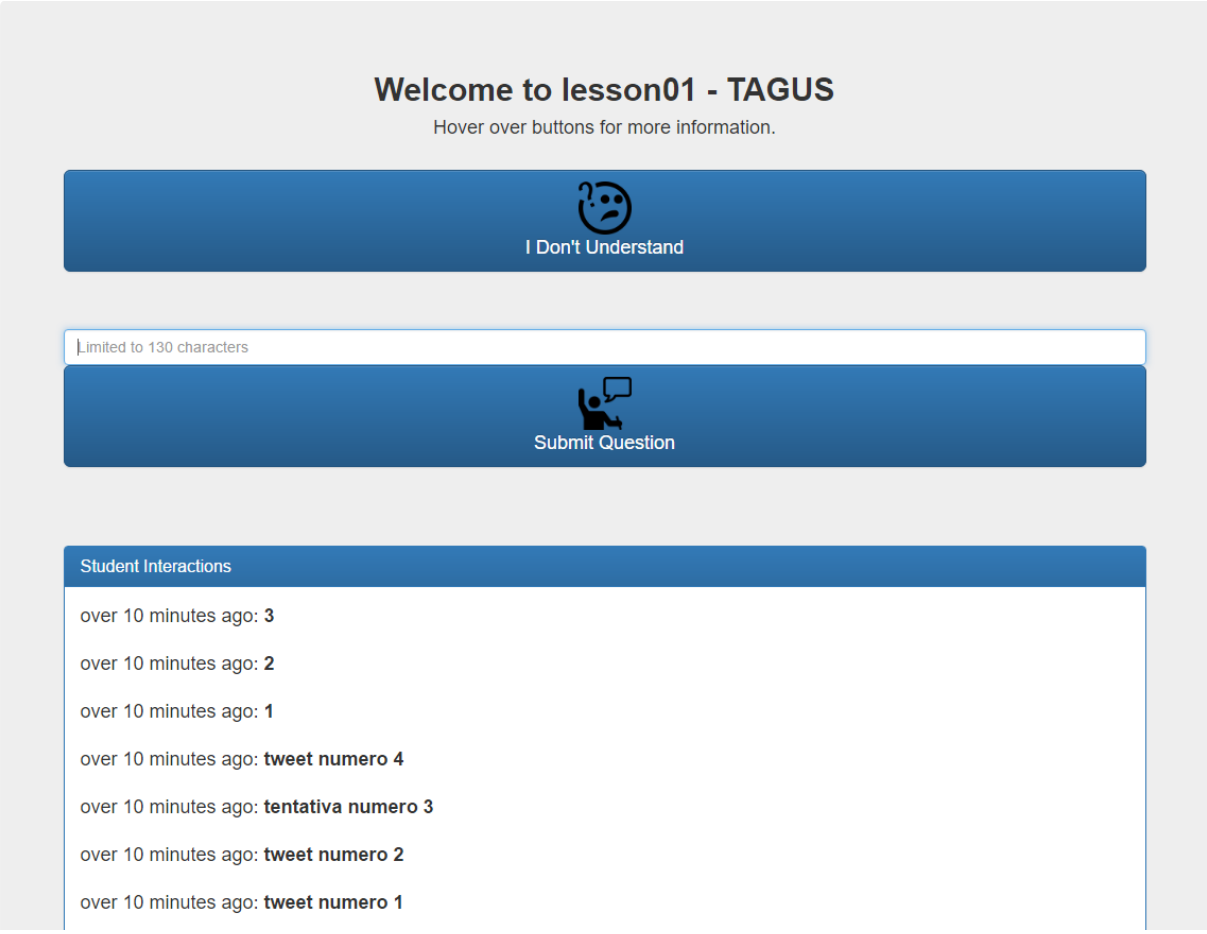

Fig. 2. Student Page

know more and is limited to 140 characters, the size of a twitter message. This restriction is necessary as it forces the student to be direct plus it allows for twitter integration on the instructor side. Each time these buttons are pressed they send a tweet to an account that the instructor owns. This integration will be explained further in the following subsection. Bellow this are all student interactions in the current lesson, so that everyone can follow along with all interactions made. All interactions are completely anonymous for the students, only the instructor can verify who made them. When the instructor sends a question, the students are forcefully redirected when one to it.

Students are then presented with a question and have exactly 1 minute to submit their answer or it will not be counted. After answering, or time expires, they are redirected back to the previous page. The answer options are shown in a randomized order to hamper student copying.

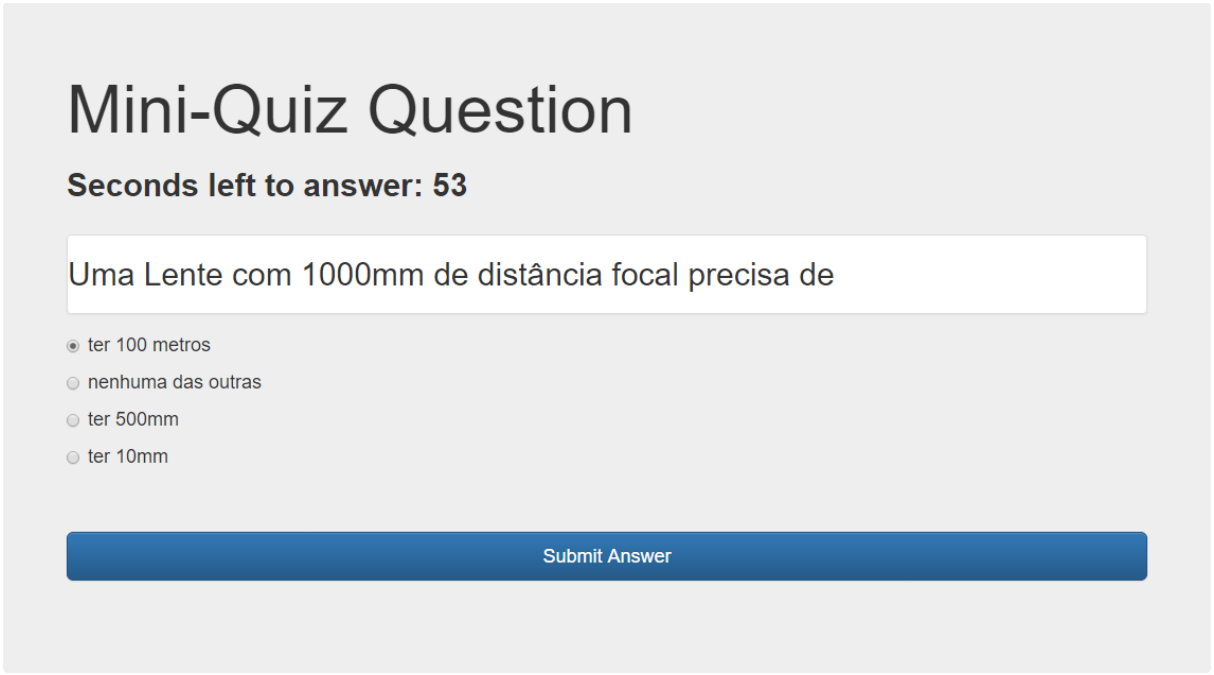

Fig. 3. Question Page

3.2 Instructor Side

The instructors require no tokens, and so are redirected to their appropriate page upon logging-in with their Fénix ID.

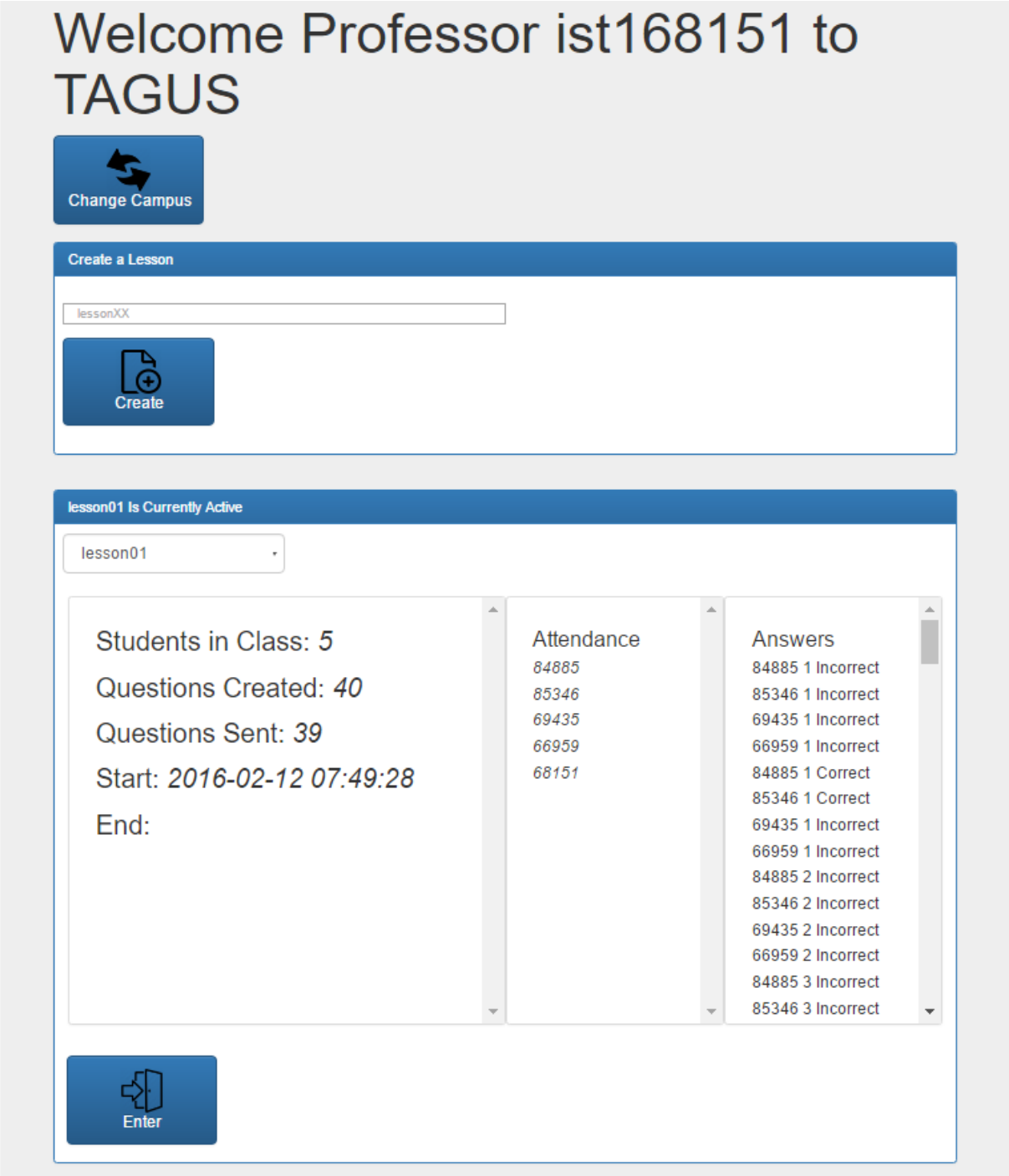

Fig. 4. Instructor Initial Page

This area, figure 4, is restricted to students. It is hard coded to only accept specific Fénix ID numbers, in this case the instructor's. Here the instructors can change between the two campi, Taguspark and

Alameda. Create a new lesson or enter an existing one. There can only be one active lesson per campus at a time, so the page indicates if there are any open lessons. Furthermore, upon choosing a lesson to enter, more information is shown about it. It shows how many questions were created and how many were sent, start and end time of the lesson, students who attended and their answers to each question sent. This allows for instructors to quickly do a summary of the lesson, or do their end of class duties.

Fig. 5. Instructor Lesson Page

Upon entering a lesson, Figure 5, they are presented with a real time number of the number of students registered in this lesson followed by 3 main areas, the question queue, the Lesson option and the student interactions. The question queue shows, by order of creation, the next question available to be sent and the previous question sent. It is this way so that the instructors can create questions based on their slides. If they want to create questions for slides 10, 14, and 25, they should create it in this sequence so that it will align with the lesson and facilitate sending them. The first row of buttons are related to the question queue, they allow to send the next question, review the statistics of the previously sent question, sending a quick question, and skipping backward or forward in the queue. Quick questions are standardized to allow for a quick survey of the classroom, their tittle is quick question and the answers are option 1 through option 4. If the instructor desires to know something about the class then he can

indicate in the white board what the options 1 through 4 mean and quickly send it out to review the results. The skip buttons are there in case something goes wrong. If the instructor forgets to send a question or does not want to send it for some reason, he can skip that question entirely or revisit it later. First in the lesson options is the create a question button, figure 6, which allows for multiple question, true/false or open answer which are then inserted at the end of the queue.

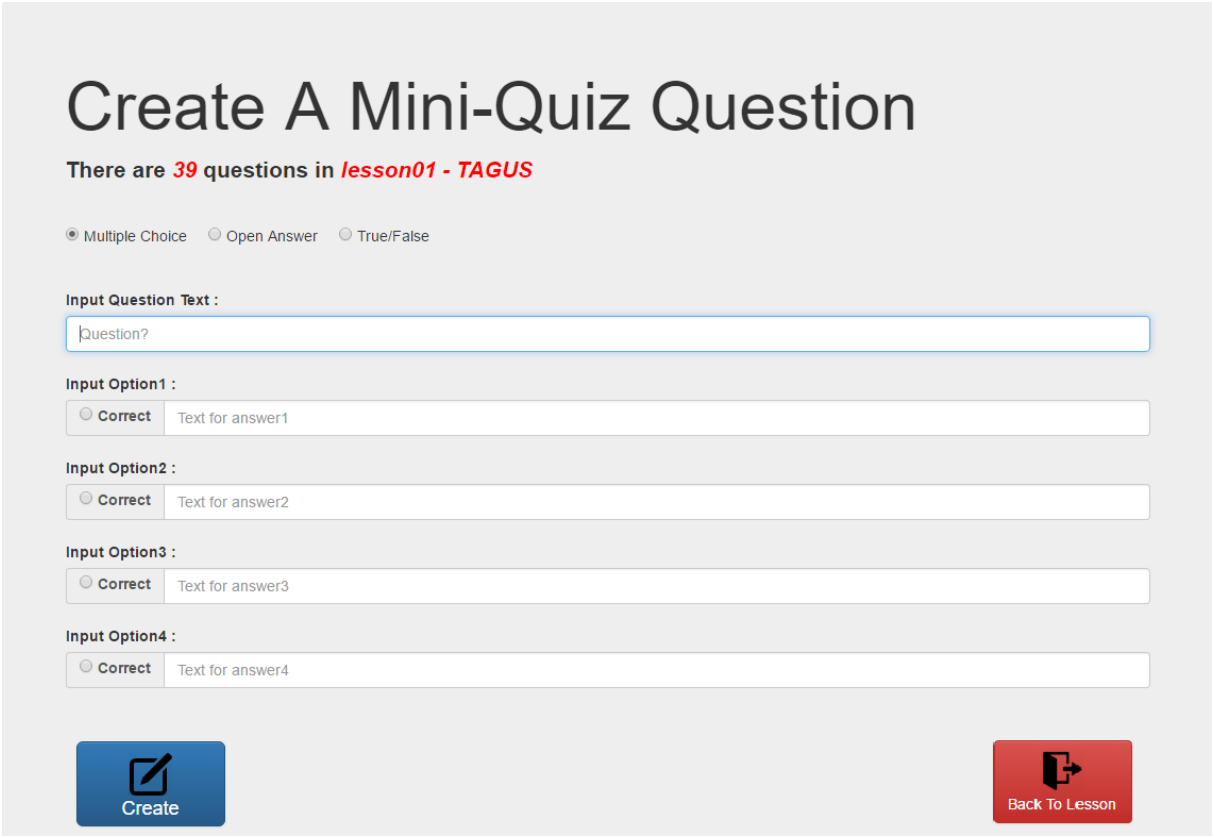

Fig. 6. Create a Question

List questions, figure 7 will show all the questions in order of creation, and allows for them to be sent out again, to review their results, to edit or delete them.

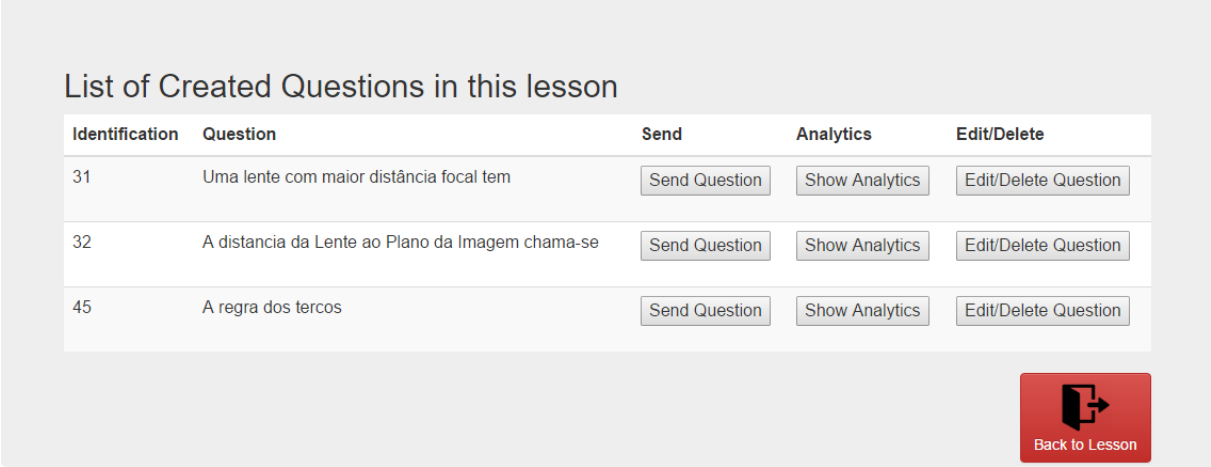

Fig. 7. Question List

Show QR code will open a QR code in a new window that the instructor can show to the students to ease the token acquisition process. The final button deactivates the lesson, so that students can no longer enter it, and creates 2 files. The attendance file, which lists the students, their entry and exit times. The Question answers file which lists the students and their answers to each question sent. This is the same information that is shown in the lesson selection but it is in file format for posterity. At the bottom are the same student interactions as the student side adding the student ID, but the instructor has another way to keep track of this. By having a smartwatch connected to the PCM twitter account via their smartphones, the instructors can receive these interactions via their smartwatch by allowing notifications from twitter. This notifies the instructors in a non disruptive way and is quickly available for them to read when appropriate. It also allows the instructor more freedom, as there is no need to be in front of the application at all times.

Fig. 8. Twitter-Pebble Integration Example

Finally the instructor can access the results of every question in the following format, and can show it to the students. The correct answer is always shown first here, followed by the other ones.

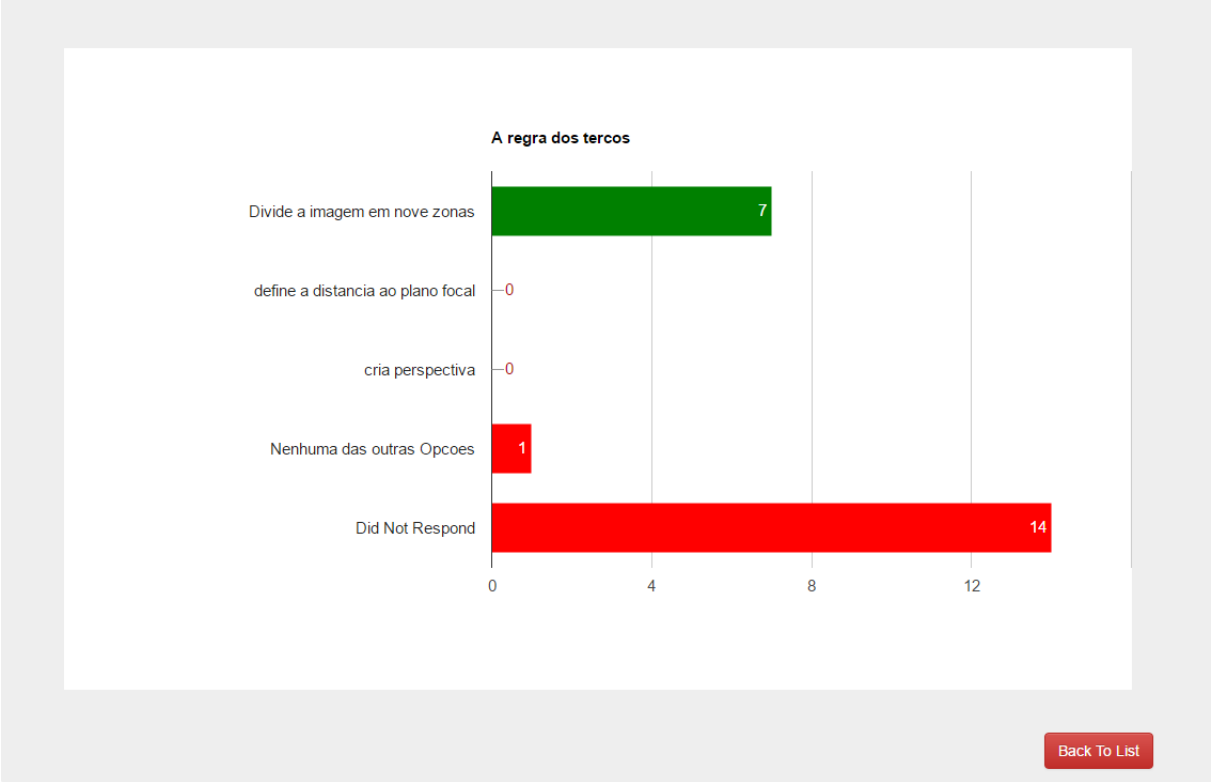

Fig. 9. Question Results

Also, due to my proximity with TagusPark campus, this solution has only been tested there. LiveClassroom is able to function correctly in Alameda, but the token acquisition process needs to be tested and refined for those specific classroom conditions.

3.3 Database

Users and lessons are split in their respective table by their Campus ID, this model assumes that an Alameda student will only attend Alameda lessons. When a student successfully enters an active lesson, an attendance registry is created in the Attendance table. These records are what is shown in the attendance file that is created when a lesson is closed. Each time a student interacts with the instructor in an active lesson, these are stored in the interactions table. This is the information that is shown in the student interactions box on LiveClassroom. Each lesson will have various questions associated with it, and once sent, each question will have multiple answers, one from each student. MiniQuiz_Answers contains the information that is shown in the answers file created upon closing the lesson. The Campus table contains only 2 entries, one for Alameda and Tagus.

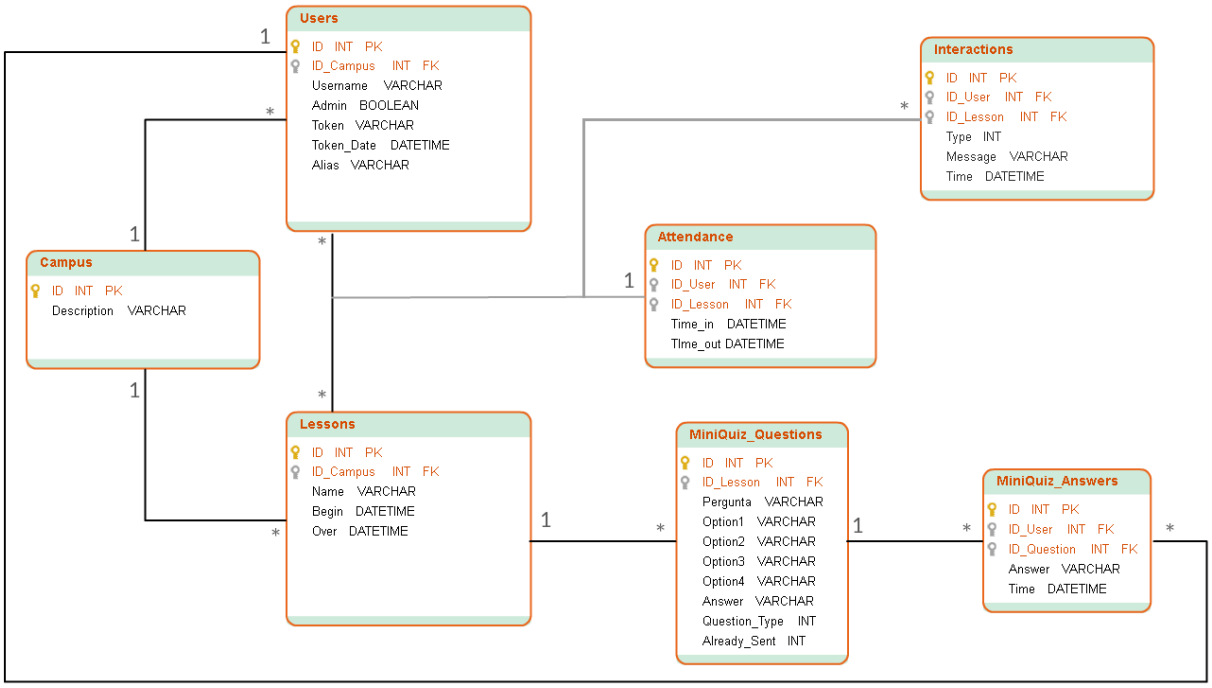

Fig. 10. Database design

3.4 Prototype Evolution

The initial prototype started right after completing the thesis project, and is shown in it's entirety on appendix B. I intended it to be more of a learning experience, and to acquaint myself with the environment. It used very basic formats and assets, and it served more as a proof of concept than anything else. There was no connection to Fénix, it was just a private mysql server and an apache server. It also did not adapt to the screen size, so mobile users were not contemplated. It did follow the same thought process, after logging in it would separate students and instructors via hardcoded user name.

Students could select the lesson they wanted to enter. Initially i believed it would be beneficial for them to be able to review previous lectures, but there would only be student questions without context or answers, plus they could mistakenly enter a different lesson than the one being taught. After selecting a lesson that was active, students would need to insert a lesson password that only the instructor would give. This, however, provided no security, as someone attending the lesson could text the password to anyone outside.

Inside the lesson, figure 21, it remains somewhat similar to the final prototype. Student interactions are shown at the top, but there was no twitter integration. The text was too small, time information was too much and each time a new message appeared it would make a honking noise which would disrupt the class. Instructor questions did not appear automatically for the students. The instructor would need to communicate that there were questions available and the students would need to press the "check for questions" button to be taken to the appropriate page. Additionally there was a "submit feedback" button that would be oriented towards students giving feedback on specific slides or situations that they felt could use improvement. The question page, was also very similar to the end product. Though there were no time restrictions, so students could go look up the answer without any pressure.

On the instructors side, lesson selection lacks information, but allows the creation and entering of lessons.

Inside the lesson, figure 24, options were very limited, there was no question queue. To send a question, one would need to be created at the time and sent afterwards. There are also no quick ways to review the results. "Lesson Over" button would only stop student's attendance from being recorded.

Question creation was very limited. Only multiple answer questions were available. Selecting the correct option was prone to mistakes as one needed to write "option1" for example.

Despite all these problems, I was energized after this prototype. I felt it could be done, more importantly, I felt I could do it. That's when I restarted the whole project and began to plan how I would do the interface. So I went to the fundamentals and did task and user analysis as shown in table 2.

Table 2. User and Task Analysis

Questions	**Instructors**	**Students**
Who will use the system?	Instructors with high ability to use electronic devices	Students with high technological skill.
What tasks are currently done?	Present class. Question the students. Answer student questions. Keep student statistics.	Pay attention to class.. Answer instructor questions. Ask the instructor questions.
Desirable tasks?	Uniform and fair way to send questions to students present in class. Expedite, Analise and evaluate student statistics after class. Provide students other ways to communicate and promote engagement.	Provide a way to answer questions in a fair and just way. Provide more avenues to communicate with the instructor.
How are tasks learned?	Experience	Experience
Where are tasks done?	Class room - demanding of concentration and multitasking Personal room - relaxed and controlled environment	Class room - Constant flow of information, Multitude of distractions
Information-User relationship	Access to attendance paper Offer credits to students who correctly answer Listen and answer students.	Access to class slides Access to credits by correctly answering questions.
What devices are used?	Smart-watch, computer, mobile, projector	Computer, mobile
How do Users Communicate?	Verbally	Verbally
How often are tasks done?	Present class. - Constantly Question the students. - Regularly during class Answer student questions. - Regularly during class Keep student statistics. - After class	Pay attention to class. - Constantly Answer instructor questions. - Regularly during class. Ask the instructor questions. - Occasionally
Restrictions?	Time, multi-tasking and attention restrictions. No restrictions after class.	Time and attention restrictions
What happens if something goes wrong?	During class a work around is found. After class it is corrected.	During class a work around is found.

With this analysis, combined with the input from Multimedia Content Production instructors, I was able to identify the important tasks that would be central to LiveClassroom's design and used constantly. The following tasks are the ones that I identified as important for the instructors:

- Create a multiple choice question to be sent during class.
- Send a multiple choice questions to the students during class.
- Show last question's results to the students.
- Respond to a student question.
- Analyze student attendance and answers after class.

Instructor side focuses heavily on the ability to question the students and to analyse those answers. Now for the student's side:

- Notify the instructor that they did not understand the last section of the class.
- Send a question to the instructor.
- Respond to an instructor question.

Armed with this information and analysis I set out to create a low fidelity prototype. Appendix A contains the images that i will reference now. These were done in paint, as i felt it would be easier to rearrange and to copy paste similar functions and buttons. I tried to pay attention to cohesion and theme.

Even though figure 13 has more information than previously, it still lacked basic information for assessing students and to help instructors to make a summary of the class. The question queue was a huge benefit for the instructor, but it still lacked a skip function, in case a question was forgotten. Showing results to the students could be an interesting proposition so it was added as well later. The button order is not the best here, so for the final prototype, it was divided as question options on top, mostly related to questions and functions that would be used more often during a lesson, and lesson options on bottom, which would mostly be used outside the lesson. This is a close approximation of what was tested live during some lessons to evaluate the approach taken. This led to some minor changes for the final prototype, such as using cookies instead of sessions and correcting coding logic mistakes.

4 Results

4.1 Evaluation Methodology

LiveClassroom functions were incrementally tested throughout the second 2015/2016 semester, during PCM lessons, in the environment on which LiveClassroom would be used. I was present during the Tagus Park class lectures to ensure that everything worked according to plan, and empirically analyze how LiveClassroom performs and make on-site observations.

At the end of the semester, students filled a short questionnaire related to their overall experience with LiveClassroom.

After all this, an additional user test was made to completely test all of LiveClassroom's features at the same time, during a simulated lecture.

4.2 Results

During the semester I was present in almost every single lesson, during that time I was taking notes and counting how many interactions where made by the students and how many credits were earned by the students. The following graphic shows just that. It is clearly seen that the number of interactions decrease over the course of the semester; there are several reasons for this, mid and end semester exams, other course projects and general drop out of students. The important thing to note is that, by the end of the semester, some students where already capped off on their extra credits earned by interacting and answering questions, openly refusing to accept any more because it would make no difference. This confirms what was observed during the semester, and the research made beforehand, that, without any technological aid, only a handful of 4-5 students would consistently interact with or answer the instructor. The initial high interaction numbers relate a lot to those students desire to obtain those extra credits quickly, but also to purge some doubts concerning the way classes work and how the course will operate. During these initial 2-3 lessons, more students would interact but only to dissipate these course operation doubts, and would only interact once, while the topic was being discussed, while course subjects were barely ever covered by students other than those mentioned above more prone to doing so.

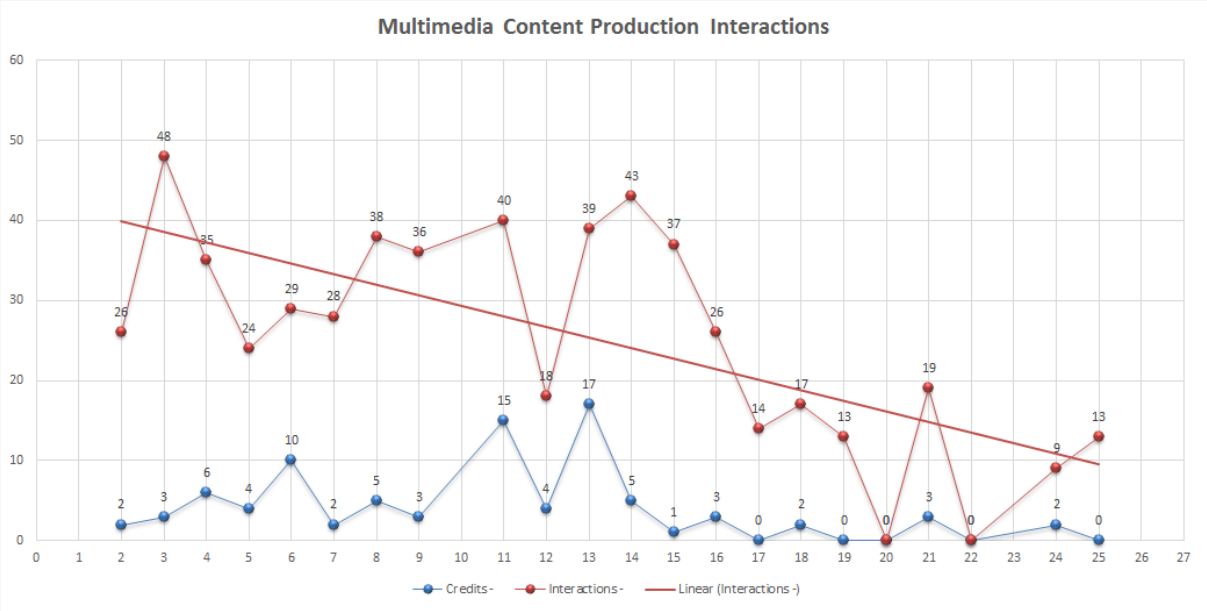

Fig. 11. Credits and interactions throughout the semester

After these initial lessons, it became very regular, mostly those handful of students would interact while others very rarely would ever say anything. This validates previous research and confirms that LiveClassroom's ability to provide equal opportunity for all students to earn credit to be a valuable feature that would only encourage student attention during class. However, this also means that the way credits are given to students for correctly answering a question would need to be restructured, so it would not cause every student to cap the credit limit too soon, as that would destroy some of the benefits

that LiveClassroom could have. Another issue with the way that these extra credits are handled now is that they depend too much on the instructor, it could happen that the QR codes used to obtain these credits are forgotten somewhere and they cannot be handed that day, as shown by the days where there are no credits given, or the instructor gets too immersed in giving out the lecture content that it could be forgotten causing a higher number of credits the following lecture. LiveClassroom, by being online, always available and using new technologies could eliminate or at least mitigate these issues to create a more consistent and fair environment for both students and instructors. It could benefit the students to know that each lesson they would have a set number of chances to earn those extra credits.

By the semester's end, I proceeded to create a really quick questionnaire to get more student feedback. It was comprised by the following 6 questions:

- If you had a way to pose anonymous questions to the instructor, through a personal device during class, would it improve your course performance?
- Was the login/token acquisition process simple?
- Related to professor questions, were the options and question text clear?
- How much would LiveClassroom help improve your learning during class?
- How would you rate LiveClassroom's simplicity of use?
- Do you have any suggestions/comments/improvements?

Since this was during exam season and the semester was ending, there was a somewhat low turnout in responses, only 12 students.

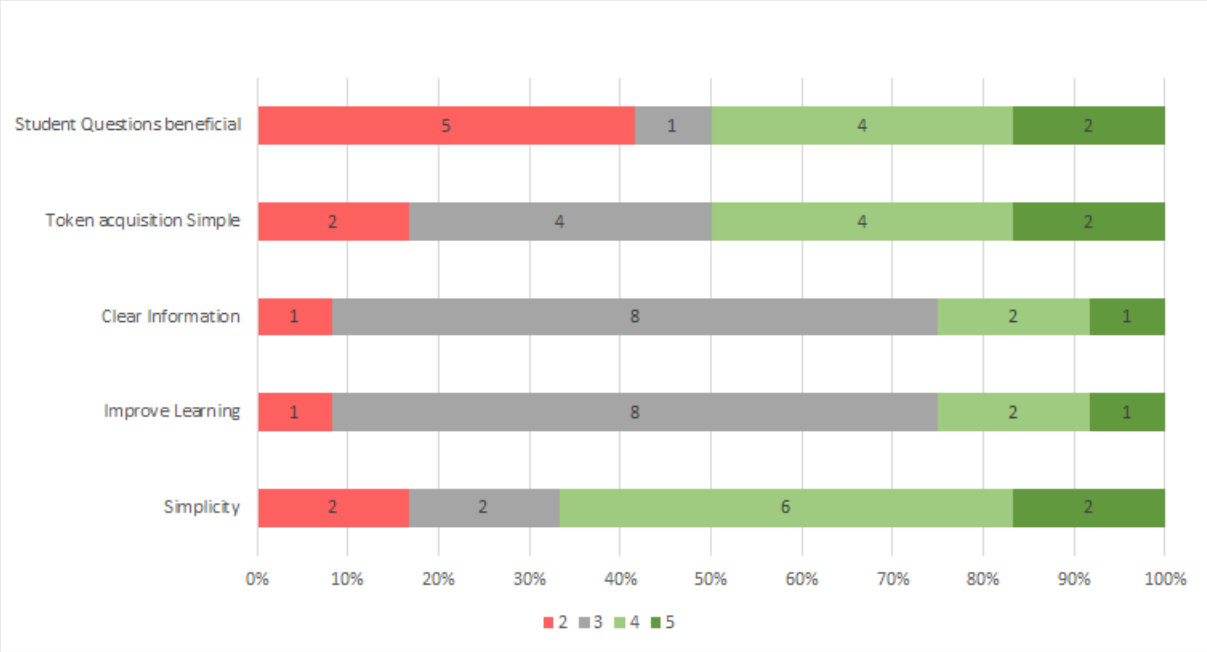

Fig. 12. Post Semester Questionnaire Results

As seen on the graphic above, a simple interface has been achieved as 70% of users considered it as such. Students found the information to be somewhat clear but it could stand to have some im-

provements. As such, text was made bigger and a clearer divide between the different options and the question text was implemented. They also found that it could slightly improve their learning, which would be a great motivator to keep them paying attention during a lesson. The token acquisition process could also use some improvements and some students suggested the use of QR codes to simplify the process, they could use their mobiles to access their token quicker with the QR code, then use LiveClassroom through a laptop. These suggestions where implemented for the final design. Student questions are split, half feel that it would not help their course performance, while the other half believes it would. Since this feature would be primarily to promote interactions for shy students, I believe that this result is encouraging. That maybe this demographic would find it helpful, while those that are comfortable with live interactions could still ask them the way they prefer.

4.3 User test

Since the tests above were few and limited in scope I decided to do a usability test with 8 friends, where I would play the role of the instructor and would give a 40 to 50 minute lesson and my friends would play the role of the students. Since this was after the semester, some people were already on vacation or still in exam season so it was hard to find more people to give their time. During this lesson there were instructor-student questions every 10-15 minutes. Students were split into two groups, one with the use of LiveClassroom and the other without, for comparison. Clicks and pressed keys were monitored during this lesson.

To promote engagement and increase student participation actions needed to be quick, clear and distract as little as possible, so I was keeping track of efficiency and effectiveness. For the student side I was tracking the following:

Instructor-student questions:

- Answering an instructor question should take at most 1 minute.
- Students should not have more than 5% of mistakes.
- Students should do at most 3 clicks.

Student Instructor questions:

- Sending a question to the instructor should not take more than 30 seconds.
- Students should not have more that 5% of mistakes.
- Students should do at most 2 clicks.

Overall:

- 90% of tasks should be completed in their first attempt.
- Students should not have more that 10% mistakes.

For the Instructor side I was tracking the following:

- Upon receiving a student question, it should be accessed and read in less than 15 seconds.
- Sending a question to the students should take 1 click and have less than 5% mistakes.

- Showing the results graphic should take at most 20 seconds and need at most 3 clicks.
- creating a question should have less than 10% mistakes

After the lesson I asked the "students" to answer some questions regarding LiveClassroom:

- Do you consider the interface to be hard to use?
- What is your opinion on the colors used in the interface?
- What would you improve on the interface?
- Which task would you consider the hardes?
- What other features could be usefull?
- Could you keep up with what the instructor was saying as you were writing the question?
- Did instructor-student questions have impact on class flow?
- Did student-instructor questions have more impact on class flow than raising a hand and ask it normally?

Since I had made the interface I was worried that the instructor side results would be skewed, so I asked the "students" to do some instructor tasks:

- Create a lesson.
- Create a question in a lesson.
- Send a question.
- Obtain results and analyse the answers.
- Close the lesson and analyse answer and attendance files.

These tasks will serve to get an overall reaction and perception of the interface, not to count or analyse mistakes and clicks, since most of these functions would be used during a lesson, which I could not replicate for 8 users.

And finally I created a written test, with 15 multiple choice questions to test the users on what they learned.

Now onto the results from these tests, in the same order.

During this lesson, 9 instructor-student questions were send, giving a total of 36 answers. There was an average of 28.75s to read the question and respond accordingly. There were no errors, such as submitting unintentionally. 2.25 clicks was the average to respond, some mentioned later that they would click on the initial one they thought was correct and then change after reading the question a few times. With these results, instructor-student questions fulfilled all the requirements I set up.

There were also 43 student-instructor questions of which 26 where through LiveClassroom and 17 through normal discourse. The average time to write was 16.25 seconds, with a 5.8% of mistakes, as 1 person pressed the button without having any text written, this triggered a warning on the student side but would not send anything to the instructor. The average number of clicks was 2.05, accounting for the above mistake. These results also meet the requirements except the mistakes, which were a bit over the limit, but given that only once did this person made the mistake I think the criteria was met. This shows a 20% increase in interactions using LiveClassroom.

Out of the 26 interactions there were 2 errors. One was pressing the submit button without having any text written, and the other was sending a “I Do not understand” by mistake. Meaning that there were 6.25% of mistakes while taking actions, and 98% completion of tasks on the first try.

For the instructor side there was no way to time how long I took to read a question during class, so later on I reread some questions and timed it, there was an average of 6 seconds. I can say that during the lesson it was strange to have to look down at the screen to read the information, which prompted me to introduce twitter integration with the smartwatch, so i wouldn’t have to stay in front of the computer at all times. So it is important to note that this twitter integration was not tested in a lesson environment due to time and semester restrictions. Sending a question took always 1 click, and there were no mistakes. Showing the graph always took an average of 13 seconds, and needed only 2 clicks. There were no mistakes when creating questions.

Even though all the criteria were met, showing the graph still had an impact on class flow, so it was rearranged to only take up one click and take less than 3 seconds.

Onto the questionnaire. The users did not consider the interface difficult to use, as it is has limited actions , but it looked rough and a bit like a prototype. The colors used looked fine but again, could use some overall polish. In terms of improvements, the users mentioned the overall polish again and add some other utilities common in other sites, like pressing enter to submit instead of clicking the button. Users considered the instructor-student questions to be the one to require more brain power but not difficult in terms of usability. They mentioned that improving the login process could be usefull. A dip in attention was mentioned while they were writing the student questions, but since the overall time to write is short it did not impact much. Instructor questions were helpful in consolidating information that was just introduced, easing the process of memorization. Student-instructor questions also had about the same impact on class flow as the normal spoken questions.

Users felt that the instructor side is definitely more complex than the student side, again it felt unpolished, and there seems to be a lack of statistics and helpful numbers to assist the instructor. It takes longer to get used to the interface, but overall everything was relatively easy to accomplish.

Finally, the written test. 4 of the 15 questions inserted into the written test had variants of the LiveClassroom questions during the class. Example: LiveClassroom question: What is the name of the castle owned by baron Y? Test Question: The Castle X was owned by which baron? Students who used LiveClassroom had 100% accuracy on these questions while the other only had 50% on these. Overall students who used LiveClassroom has 13% better score than those who did not.

4.4 Results Discussion

First let us review the initial objectives:

"I developed a tool-set to support bidirectional communication and evaluation to promote student engagement in lectures, improve teaching in blended learning settings while increasing student participation in simple and unobtrusive ways"

As stated in the results section the number of student interactions steadily declines throughout the semester, in a normal setting without LiveClassroom, meaning that students become less engaged and

interested. Given that students in the questionnaire felt that LiveClassroom could help improve their learning, I think that would directly relate to an increase in communication and engagement. Also, the fact that paying attention in class could visibly impact their credit score, by answering instructor questions, would not only motivate the student but also keep them interested and yield better results overall. Additionally, the spark of using new technology and new applications could fuel student interactions, by experimenting with it and realizing that interactions are completely anonymous. This is corroborated by the user test, the Users who used LiveClassroom had more interactions than the ones without and scored 13% higher in the final test. Instructor-Student interactions would definitely support evaluation of students, but also, instructors can clearly see when a part of the lecture is problematic. By reviewing the number of "I do not understand" messages and student questions they can see where students falter, where the lesson could stand to become clearer or where the slides could use some improvement.

The number of users in the user test is low, and cannot accurately reflect the environment nor the conditions of a real lesson, but I think it shows promising results that have the potential to be even better because in a real lesson students actual have a stake and want their results to be the best they can be. The fact that students can see that they have equal opportunity to earn credits, don't have to be the quickest and can take some time to think up their answer will be a motivating factor. And, as they see their lesson scores keep up with other students, it might increase their self-esteem enough that they could ask more questions and keep feeding this cycle. These points, I think, fulfil "bidirectional communication and evaluation to promote student engagement in lectures, improve teaching in blended learning settings while increasing student participation".

Since distractions are ever more prevalent, LiveClassroom does not need to add to that, so, the student side of the application is as simple as possible. They have 2 options to interact, one is a simple button that performs the action it displays, "I do not understand" and the submit question which is limited to the size of a tweeter message. Instructor questions appear on their screen automatically, requiring no action from the student. This led to 70% of students considering the interface simple. The instructor already has a very demanding task during a lesson, that takes massive amounts of multi-tasking, again, LiveClassroom does not need to add to that. Questions should be created before a lesson, in the order that they should be sent to the students. During the lesson the instructor should only be pressing 2 buttons, the one to send the next question, when appropriate, and the one to display results, if they deem necessary. Questions can be skipped forward or back in the case that one is forgotten. Furthermore student questions can be read easily, by newest first order, on the application or on their smartwatch, by integrating it with the PCM associated twitter account. These complete the objective of a tool-set that is simple and unobtrusive.

5 Conclusion

Lack of student interaction and engagement are a real problem in the current classroom pedagogy, some students are afraid of being wrong in front of their classmates, others have questions but hold off on asking them hoping they will be answered in the coming slides, and when they are not, the student might feel like the conversation has moved on and their question would no longer be relevant and seen

as disruptive. While others have no such problems and dominate the entire discussion, being the sole communicators with the instructor. Is there a way to increase student interaction and engagement in an unobtrusive and simple way?

Student engagement is very poor in computer science courses leading to disinterested students, who do not participate or try to actively learn from what is being said, but this can be undone.

By reviewing and analyzing previous research on backchannels, it can be noted that they increase student participation and interaction significantly. The introduction of anonymity into these systems allow for even more students to participate but also make anti-social and negative behaviour apparent. Degrees of expression also have an influence, higher degrees allow more communication capabilities but require more attention, while lower degrees limit communication but are easily interpreted.

Microblogging systems, like Twitter, have the possibility of being important in a classroom context, the fact that it is real-time, available to a wide array of devices and has limited text characters makes for a more dynamic class by making communication easier to interpreter by both students and instructors. Since twitter is a social network and a widely used platform by all kinds of companies, it can introduce another avenue for distractions, as the students have easy access to various news and information that is no way relevant to the topic of the lecture.

Multitasking and distractions are a problem in class and will only get bigger as computers become evermore ubiquitous in the classroom, not only for those that are using the device but for others who have a clear view of others devices. Students who are uninterested in the class or find the lecture too difficult will want to find escapism. To combat this, the class needs to be more engaging, providing easier and safer means to interact with the instructor. A more creative and engaging class will make more attentive students.

Blended learning and gamification increases student performance of students who are enrolled in classes with this teaching pedagogy, and they are also widely preferred by students. These pedagogies create better motivated and invested students in the course, but the MCP course has only implemented an off-class solution with Moodle, which is independent of each lecture's environment or students. The addition of a real-time solution during class will certainly not only improve student performance and engagement but also the fluidity of the class.

With my approach, inspired by backchannels discussed in the related works section, I am confident that the proposed solution simplifies, streamlines and enhances student participation and engagement all the while helping students learn and earn credits in fair and equal terms and aiding the instructors by facilitating feedback from the students.

The final prototype fulfills all the objectives initially proposed, it features anonymous student-instructor communication with the help of twitter to allow an easier read for the instructors. Allows for instructor-student questioning during class with limited class flow interference. It keeps all attendance records and student answers to ease the instructor's out of class work flow.

Regarding the functions of LiveClassroom that were tested with the students, a post semester student questionnaire revealed that:

- The interface was simple.

- Information could be more clearly displayed.
- Students feel that LiveClassroom would benefit their learning.
- The token process was acceptable but could receive some improvements.
- Students are unsure if student-instructor questions would be helpful.

Further user tests showed an increase in interaction for students who used LiveClassroom versus those who did not, translating into a 13% better score at an after lesson exam.

Even though some features where not extensively tested throughout the semester, the ones that were tested turned out a positive result by their final build. Attendance recording was accurate as only people present in the class were recorded. The login process was functional but was overly extensive. And students were able to receive and answer instructor questions when one was sent. Obviously some new features have been added and perfected that also require more testing and use, but overall I believe that LiveClassroom is beneficial to the classroom, at least from an instructor-student perspective. Since student-instructor questions were not tested, and students seem doubtful of it's use, it is hard to predict if it will have much use, but steps have been taken to ensure that if it is used it has the least amount of impact on class flow and instructor time and attention. In the end, I am hesitant to call LiveClassroom ready for deployment or ready to be used consistently throughout a semester. More testing is needed to guarantee that everything works as intended, but initial results are promising and enhance the blended learning aspect of the MCP course.

6 Possible Future Improvements

As explained before, the token acquisition process was unrefined and lengthy. This provides ample ground for improvement. A faster way to provide access tokens for the students would be desirable. Usage and explorations of captive portals could be an important feature to add. The Captive portal would redirect to the right site when opening a web browser while connected to the instructor's network. I tried to make this work on a software level but it is not possible, some external hardware is necessary.

Interaction with the instructor could also be expanded. As of now there are only 2 possible ways for this through LiveClassroom. Dividing the "I Do Not Understand" button with other alternatives, such as "speak louder" or "repeat the last slide".

A way to mute students who might be engaging in anti-social behaviour during class would also be a necessary safeguard.

Additionally, it would be beneficial for LiveClassroom to be integrated with the existing gamification of the course and the leaderboards, which are used with Moodle, to further enhance student motivation, by providing new and specific badges that relate to student-instructor bi-directional communication.

Finally, some aesthetic and quality of life improvements could be made. By providing ways to keep the users information saved while navigating the website. If a student is writing a question, and is interrupted by a mini-quiz, that information is lost. An overall face-lift and a more unique cohesive identity would definitely improve LiveClassroom.

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A Low Fidelity Prototype

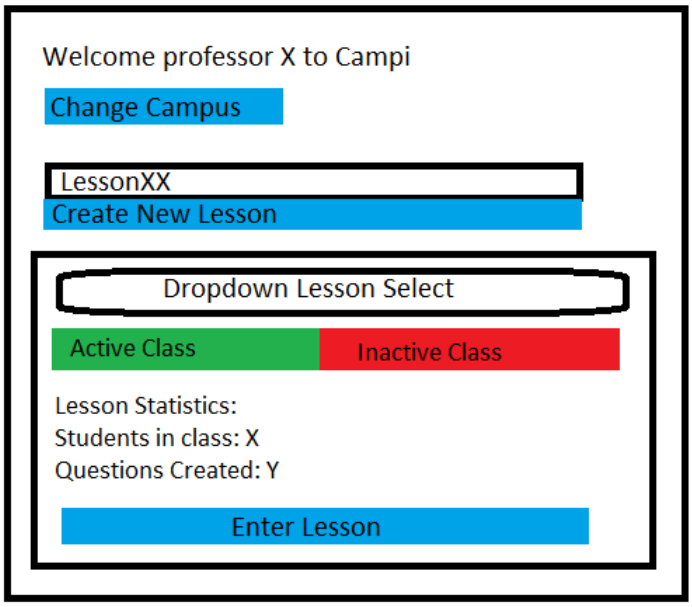

Fig. 13. Lesson Selection

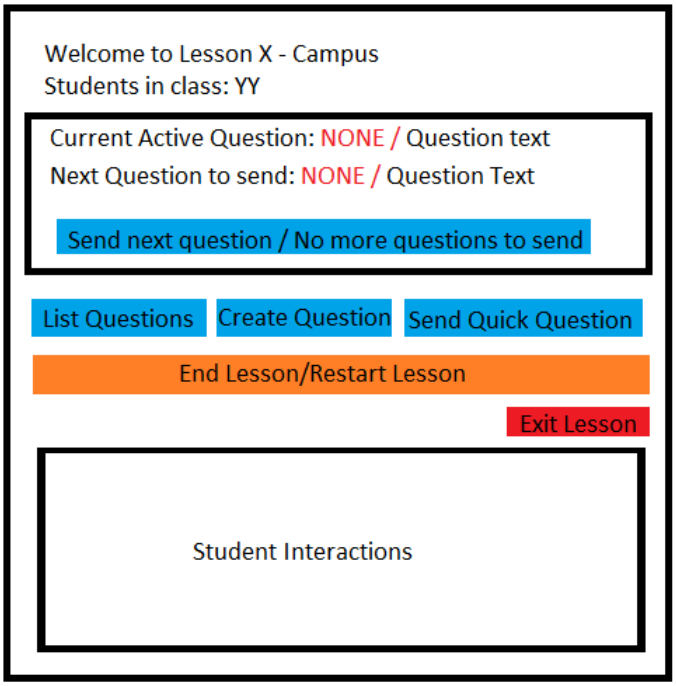

Fig. 14. Lesson Options

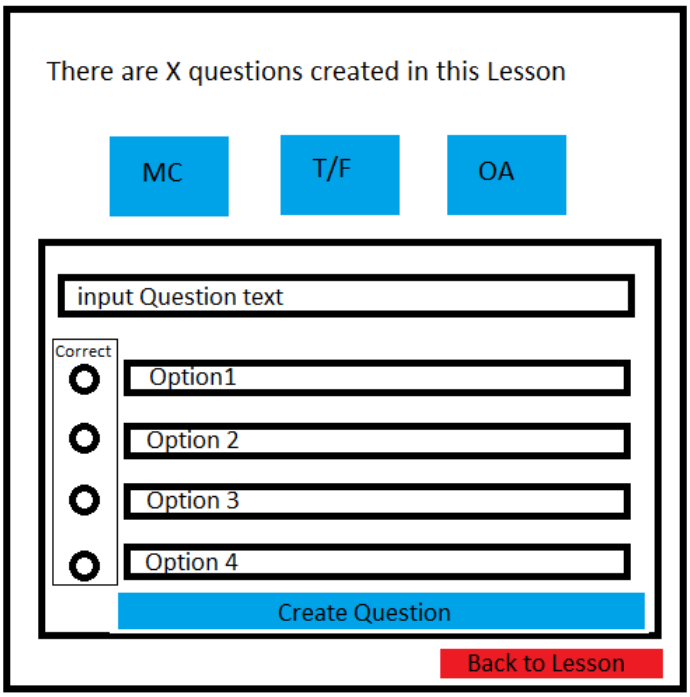

Fig. 15. Question Creation Multiple Answer

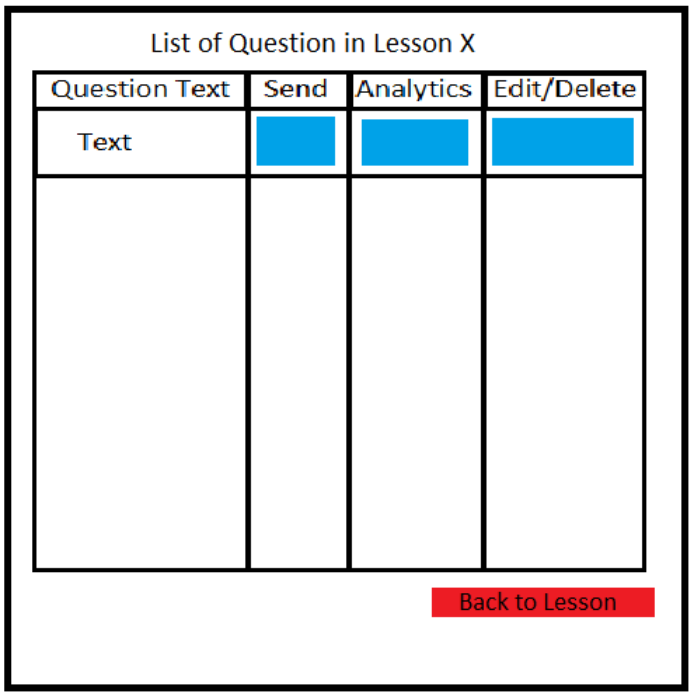

Fig. 16. Question List

Student side.

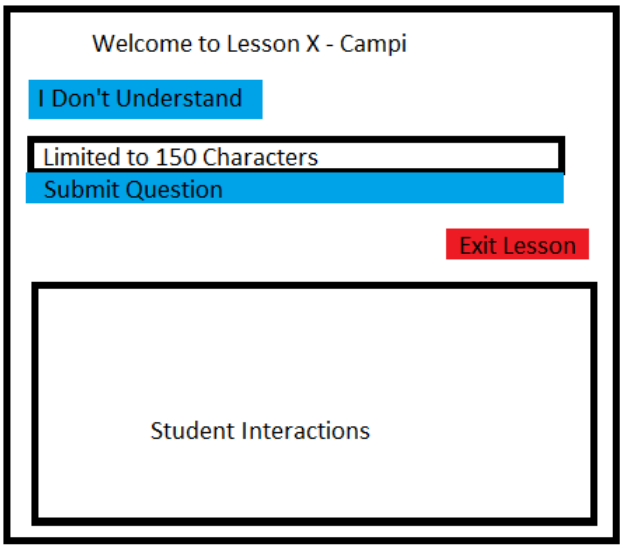

Fig. 17. Main student side page

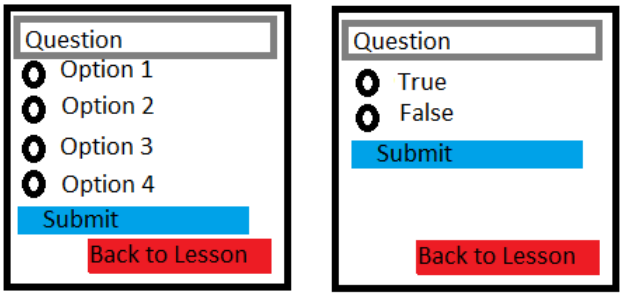

Fig. 18. Question response

B First prototype

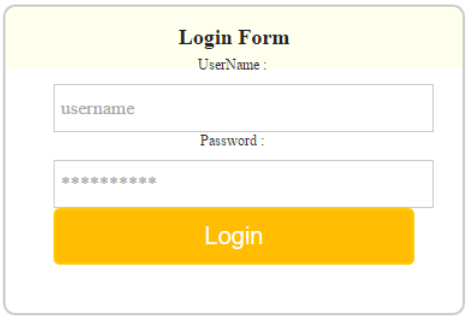

Fig. 19. Login page

Fig. 20. Student Lesson Selection

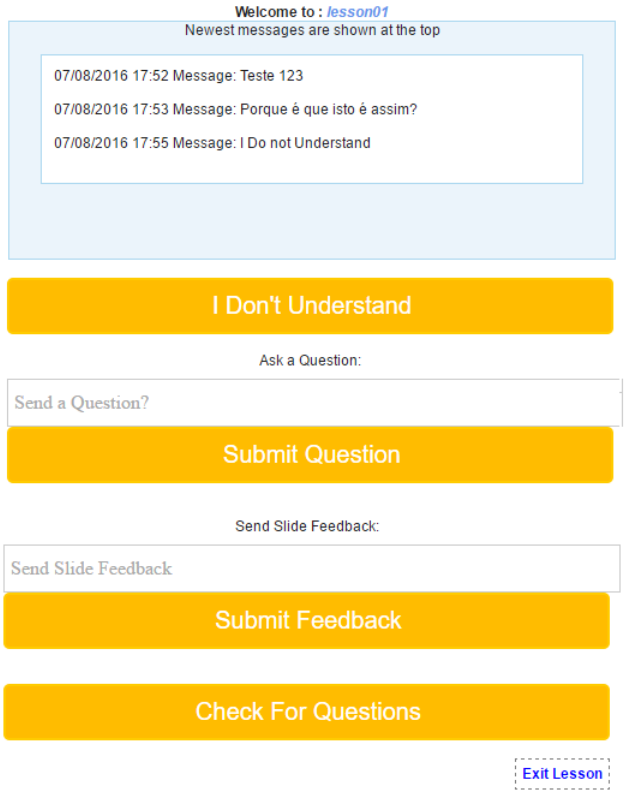

Fig. 21. Student Lesson Options

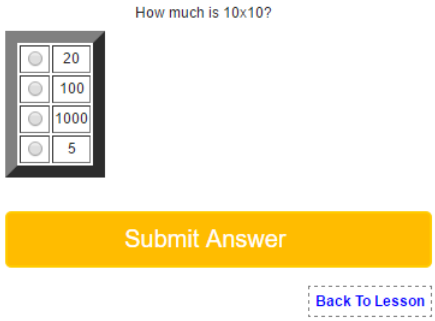

Fig. 22. Instructor-Student Question

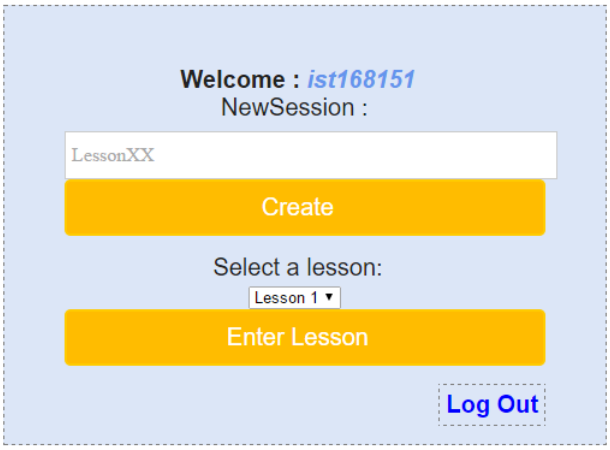

Fig. 23. Instructor Lesson Creation

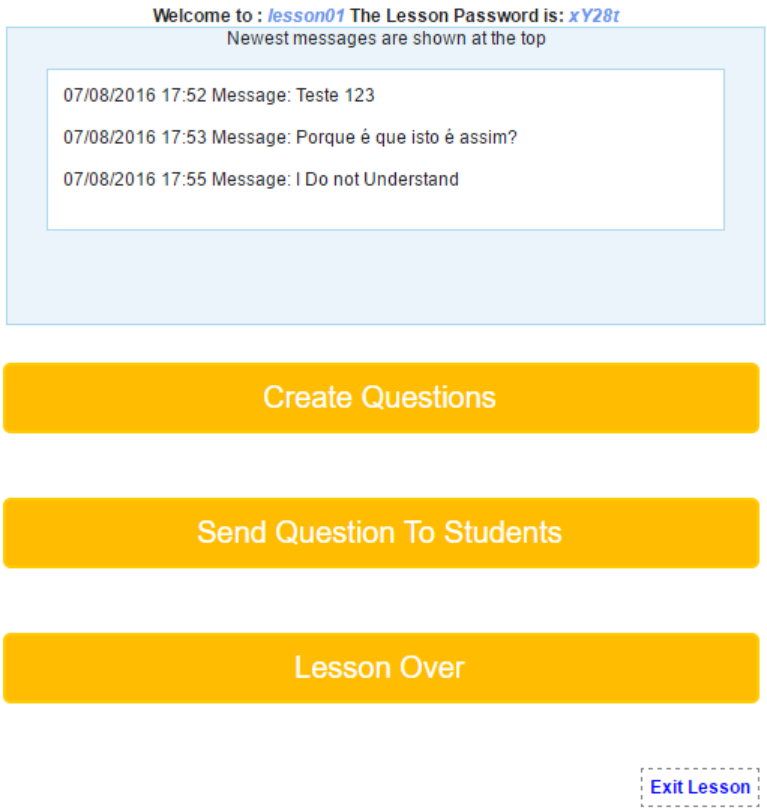

Fig. 24. Instructor Lesson Options

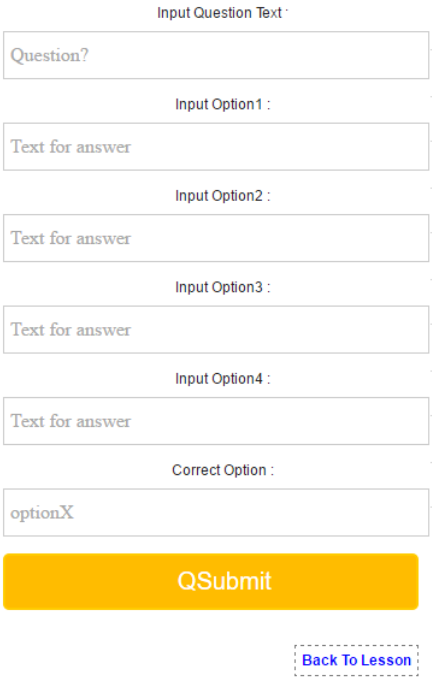

Fig. 25. Instructor Question Creation