Journal of Universal Computer Science, vol. 20, no. 1 (2014), 24-38
submitted: 9/6/13, accepted: 30/9/13, appeared: 1/1/14

Adapting an Awareness Tool for Massive Courses: the Case of ClassON

Israel Gutiérrez-Rojas
(Universidad Carlos III de Madrid / Institute IMDEA Networks, Madrid, Spain
igutierrez@inv.it.uc3m.es)

Raquel M. Crespo-García
(Universidad Carlos III de Madrid, Madrid, Spain
rcrespo@it.uc3m.es)

Carlos Delgado Kloos
(Universidad Carlos III de Madrid, Madrid, Spain
cdk@it.uc3m.es)

Abstract: In this paper we analyse the challenges posed to teachers and students in massive face-to-face classes and explore how existing solutions can be applied to these contexts. In particular, we focus on classON[1], a tool that provides teachers and students with the appropriate information to make the most out of face-to-face sessions in the computer lab. classON has been well tested in small-medium face-to-face lab sessions and we discuss some of its characteristics (current ones and foreseen) to adapt it to massive courses. As a result, we provide a set of recommendations for adapting tools to support massive face-to-face learning activities.

Keywords: teacher awareness, massive learning environments, face-to-face teaching, just-in-time teaching, scalability, active learning
Categories: H.5.2, K.3, K.3.1, L.3.0

1 Introduction

In the context of higher education it is not difficult to find courses with hundreds of students. As part of the course, face-to-face (f2f) lectures are given by the teachers in huge classrooms like lecture halls. In this learning setting, several problems emerge: some derived from the teaching methodology, some from the massive audience, and some from both.

In most traditional massive face-to-face classes, teachers apply learning methodologies in which students play a passive role and are supposed to learn by listening. Usually, in these lectures, there is poor student-teacher interaction, which is mostly unidirectional except for the small amount of questions a few brave students dare to ask. This also leads to low awareness on the students' progress and assimilation of the knowledge by the teacher. Moreover, massive contexts also impact the interaction between students themselves. In fact, interaction among students

[1] http://www.class-on.org/

during class is considered negative as it distracts the attention from the teacher's explanations. The lack of (quality) interaction between students also hinders the possibilities of peer learning and the emergence of a community, as the methodology remarks the individual conception of the learning process.

Regarding the ”massive” aspect, even if students tried to actively participate raising questions, only a few of them will succeed due to the scarce time allocated for the lecture compared to the number of students. On the other hand, although the teacher's explanation could fit the level of knowledge and pace of some students, it is difficult to adapt the flow of information to the learning needs of a majority of them. Additionally, it is also hard for the teacher to adapt the content to the huge range of students' profiles, since it is not easy to be aware of the details of the learning process of every individual. These problems scale up in massive settings.

Several technology-based solutions have been proposed to tackle these problems (see next section for details). However, they usually fail to offer a complete solution, either because they focus on just one specific issue, failing to address others; or because they are not scalable to massive contexts; or because they are not affordable to implement in practice due to particular requirements and/or expensive hardware.

Given the aforementioned problems, the research question we are trying to answer in this paper is: *Is it possible to adapt existing tools used in face-to-face learning activities to a massive environment?* Our hypothesis is that some technology tools, exemplified by classON [Gutiérrez et al., 12], could be used in massive environments with some adjustments. To address this objective, first we have reviewed the literature (section 2) to analyse awareness tools and methodologies used to solve interaction issues in f2f learning environments. Then, in section 3, we briefly describe classON and identify the features that would make it usable in a massive learning setting, as well as features that difficult its use. Next, we use a foreseen scenario to design some improvements to be made to classON to adapt it to massive contexts in section 4. Finally, lessons learned, based on the classON case study, are generalized into a set of recommendations useful for recognizing issues with tools when adapted to massive courses in section 5. This paper finishes with some conclusions and future research lines to be explored regarding awareness and interaction tools in massive learning environments.

2 State of the art

Awareness tools facilitate teachers and/or students certain information about the learning process, improving their perception and understanding on different aspects, such as students' activity, progress, etc. Awareness allows, for example, teachers to adapt their explanations to the actual students' needs. It also allows students to compare their performance and progress to their peers', so that they can adjust their activity if needed. In general, awareness allows the different stakeholders to detect problems so that they can try to solve them and improve the learning process. Stakeholders in small courses are easily aware of the activity, progress and results. However, massive environments make understanding what is happening in the course a challenging task. In consequence, awareness tools are particularly suitable and necessary for massive settings.

Interaction (teacher-student or student-student) is one of the aspects of the learning process that can benefit most from improving awareness. Quality interaction is often regarded as critical for improving the learning process. It also becomes more challenging in massive settings, particularly teacher-student interaction. In this section, we review various methodologies and tools that apply awareness mechanisms (get to know some information about the learning process and its context, such as students' progression or questions), paying special attention to those that aim at dealing with the interaction (or lack of it) issues.

Some teaching methodologies are particularly demanding regarding awareness, such as Just-In-Time Teaching (JITT). Popularized by [Novak et al., 98], JITT defines a teaching and learning strategy that aims at adapting the teacher's explanations to the students' previous knowledge. Students fill out web-based surveys just before the class to provide the teacher with the necessary information (about their previous knowledge on the matter). The objectives of this methodology are: a) to maximize the efficacy of the session, since the teacher can adapt the content to the students' actual knowledge, according to constructivism ideas; b) to structure the out-of-class time, for the students to read and reflect about the class content beforehand; and c) to create and sustain team spirit, that is, students and teacher work as a team with the same objective. This methodology was developed for a setting with a massive lecture and addresses some of the interaction and adaptation problems. But, although JITT makes students more active in the learning process, the main role is still played by the teacher, and lectures continue lacking interaction as the role of the students is still passive.

A similar approach was followed in the Peer Instruction (PI) methodology described in [Crouch and Mazur, 01]. It was used during 10 years in physics classes, where the students had to review the materials before the session and discussed some topics during the lecture. PI increases the interaction among students, but the interaction is just with students in the same team and is lacking the building of a bigger community. Building a community of learners in a course is important because the group itself could guide worse-performance individuals to achieve better results. Besides, having contact and increasing interaction with more course colleagues can facilitate and improve peer learning.

The use of personal response systems (clickers), one of the first awareness and interaction tools, is studied in [Mayer et al., 09]. The idea is that the teacher poses multiple-choice questions (typically 2 or 3) to the audience during lectures that students answer using clickers. The objective was to make the students more cognitively engaged in lectures, and consequently obtain better grades. However, one of the main problems of clickers was the need of specific hardware that could make this solution unaffordable for massive audiences, not only due to the economic cost but also because of the logistic complexity. The purpose of clickers is shared with PINGO (Peer Instruction for Very Large Groups), introduced in [Reinhardt et al., 12]. PINGO is a poll system for large lectures, so called classroom response systems (CRS), that makes use of the personal mobile devices of the students. Although having similar purposes and benefits to those of the JITT methodology, these systems improve the interactivity of the classes (the students answer the questions posed by the teacher several times during the lecture) and additionally provide the teacher with information about the students understanding of the lecture just after explaining it, thus facilitating the adaptation of the class content. However, the interaction between students and teacher remains scarce, and the interaction among students does not exist.

Using backchannels for generating instant feedback within lectures is reported as a factor for potential success according to [Conole and Alevizou, 10], a review of the usage of Web 2.0 tools in higher education. This trend is consistent with [Yardi, 08] who notes that: *"...the specific ways in which they can influence teaching pedagogy and learning opportunities are less well understood"*. The social media tool Twitter was used by [Ebner, 11] to encourage interaction in a large lecture hall between the teacher and the students in a massive environment (around 250 students). The result of using an ad-hoc app called Twitter Wall is that it increased the number of questions asked to the teacher after the class, and permitted students' discussion on certain topics in the lecture. [Pohl et al., 12] introduces Backstage, a tool to engage students in a conversation among them and with the teacher during presentations in lectures. Students' conversations are attached to the slides of the presentation, and the teacher could review them at any moment during the lecture. One of the main objectives of Backstage is to make students and teachers aware of learning aspects in lecture sessions. Backstage addresses the problem of students feeling shy when asking questions in front of a large audience, since it implements some anonymisation mechanisms. Those approaches and tools making use of social media to improve interaction in lectures solve more interaction problems than the clickers and PINGO approaches, as they permit to open a communication channel from the students to the teacher, and enable the interaction among students during the class. However, they still maintain the same structure of the lecture, where the majority of the information flows from the teacher to the students. Moreover, some tools like Backstage assume that the learning activity has the majority of the flow from the teacher to the students, and that the teacher gives a presentation using slides.

We have analysed other tools that, although not designed for massive scenarios, were developed to improve teacher's awareness and facilitate the student-teacher interaction. [Zarraonandia et al., 13] proposes a system based on augmented reality (AR) glasses to bring awareness information to the teacher during lectures. The students use their personal mobile devices during the class to indicate their level of assimilation of the information given by the teacher. Using the glasses, the teacher observes the classroom augmented with the students learning status floating over their heads. The objective of the system is to improve communication and interaction during lectures. This system could be quite useful for teachers to catch a glimpse of the status of the students, but it does not seem to be very scalable and applicable to massive environments because the information presented to the teacher augmenting the physical space could be huge and not assimilable by the teacher. That is, the information needs to be preprocessed in some way before presented to the teacher. On the other hand, [Alavi et al., 09] uses the concept of awareness in the context of technology-enhanced learning. They analyse the interactions between teacher assistants and learners in recitations sections (sessions of problem-based activities with teaching assistants), and make use of lamps as distributed awareness mechanisms. Students use the lamps (called lanterns) in order to indicate progress (lamp colour) and to request feedback from the teachers (lamp blinking). Again, lanterns are not suitable for massive scenarios with hundreds of students because the awareness information is distributed in the space: the larger the space grows, the more difficult it is to grasp all the information. Additionally, due to the hardware requirements, the usage of this technology in a massive setting involves an important economic cost.

Methodology / Tool	**Addressed problems**	**Positive aspects**	**Negative aspects**
Just-In-Time Teaching (methodology)	- Adaptation of the lecture	- Adaptation of the lecture	- Few students to teacher interactions - No peer interactions - Passiveness
Just-In-Time Teaching (methodology)	- Adaptation of the lecture - Passiveness of the students - Interaction among students	- Adaptation of the lecture - Active learning - Interaction among students	- Lack of building community
Clickers / PINGO (tool)	- Just-in-time adaptation of the lecture - Passiveness of the students	- Adaptation of the lecture just-in-time - Active learning	- Few students to teacher interactions - No peer interactions
Backchannel / Twitter Wall (tool)	- Passiveness of the students - Interaction among students - Teacher awareness	- Active learning - Interaction among students - Teacher awareness	- Predominant teacher to students flow
Backstage (tool)	- Passiveness of the students - Interaction among students - Teacher awareness - Interaction teacher to student	- Active learning - Interaction among students - Teacher awareness - Interaction student to teacher	- Predominant teacher to students flow - Assume teacher presentation with slides
AR glasses (tool)	- Teacher awareness	- Teacher awareness	- No awareness among students - No scalable
Lantern (tool)	- Passiveness of the students - Interaction among students - Teacher awareness - Interaction teacher to student	- Active learning - Interaction among students - Teacher awareness - Interaction student to teacher	- No scalable - Economic cost

Table 1: Awareness-based methodologies and tools for face-to-face sessions

Table 1 summarises the previous analysis of the state of the art, recapitulating the problems addressed by each methodology and tool together with their main strengths and weaknesses.

To sum-up, the literature review concludes that a number of methodologies and tools focus on enhancing awareness and interaction in face-to-face classes in the pursuit of improving the learning process. Massive settings make this objective more difficult, but also more crucial to ensure quality learning. It is thus necessary to explore the potential application of existing tools to massive courses as well as the particular requirements and adjustments posed by massive contexts.

3 Analysis of the applicability of an awareness tool in massive courses: the case of classON

In this section, we analyse classON, an awareness system designed and developed by the authors of this paper. It has some similarities to the last two tools discussed in the previous literature review, as its main objective is also to provide awareness and improve interaction. The following analysis first describes the system and then focuses on its scalability features and how to adapt it to a massive environment.

3.1 Awareness support using classON

classON (in-Class Live Analytics for aSSessment and OrchestratioN) is a tool designed to help teachers and students to make the most out of lab sessions, practical sessions in the computer lab in which the students work on a hands-on assignment and the teachers move around providing feedback. classON collects information about the students questions and progress during the session, processes it and presents it to teachers and students. Students share questions and answers (Q&A) about the session topics, so they interact with other students and build community, apart from reflecting on their work. At the same time, classON allows teachers to optimize their tutoring, avoiding routine, repetitive questions and devoting more time to complicated ones. classON provides the teachers with a visualization of the physical classroom augmented with information about the location and identity of the students, their progression in the session and unsolved questions, for them (teachers) to make better informed interventions.

classON is implemented as a web-based application, see Figure 1 for supporting technology. The system is composed of 3 components:

- **Student component**. As the assignment of the session is delivered to the students as a web page, this component is embedded in the assignment. The student component main functions are: it is in charge of monitoring students' progress and questions; and it provides the students with a forum-like interface to check peers' questions about the task, answer them, vote them and ask new questions (instead of the traditional hand-raising)
- **Teacher component**. As the teacher is moving around the classroom helping the students, the interface of the teacher application has been implemented for a mobile device, concretely for a tablet (see Figure 2). Its main functions are: to present the information about progression, questions and help demanded by students contextualized in the physical classroom and attached to images of the students; and to provide intervention functionality, with detailed information about the students to be helped and a timer to measure the intervention time.

- **Server component**. This component is in charge of managing the communication among the other components, logging and processing the learning events collected from the other components.

Regarding the problems discussed previously in the introduction, the use of classON together with the methodology of active learning [Gutiérrez et al., 11] in lab sessions seems to correctly tackle them [Gutiérrez et al., 11]. It makes teachers aware of students learning progress and difficulties, facilitates the teacher - student interaction, enable interaction among students to discuss about the problems they find in the session and help to build a community of learners.

classON has been used along the last three years in lab sessions in the Multimedia Applications course corresponding to the Audiovisual Systems Degree offered in the Universidad Carlos III de Madrid. The number of students in these sessions ranged between 20 and 40 per group and professor, which, strictly, cannot be considered a massive environment. However, applying active learning with highly interactive activities has been proved a highly demanding teaching and learning setting for both teachers and students. classON benefits have been formally validated: for teachers, demonstrating that their tutoring time is more fairly distributed, and the order in which they answer students' questions is also more fair; and for students, demonstrating that classON is transparent and non-disruptive, it lets students concentrate on the assignment, and they trust that using the system the teacher will come to help them when in trouble. For more details, see [Gutiérrez et al., 12].

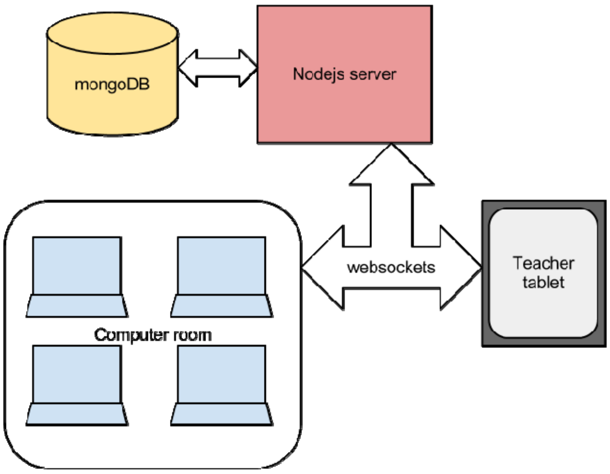

Figure 1: Scalable classON technology and architecture

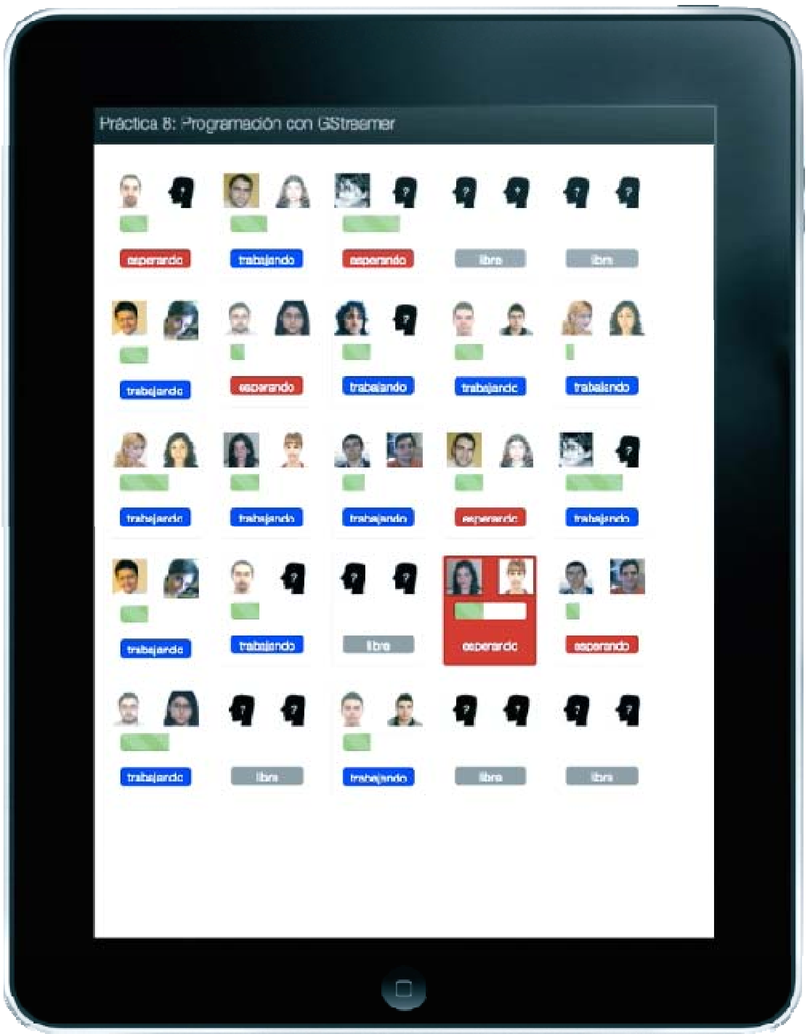

Figure 2: classON teacher's interface

3.2 Applicability of classON in massive courses

The tool has been designed and implemented for the previously described setting: lab sessions in the computer lab with around 30-40 students. However several design decisions adopted are applicable to massive environments. Here we describe a list of features that the classON system have and how they make it usable in a massive course.

1. **Student's learning and personal information**, like progression and questions, always available for the teacher. In a classroom with few students it is feasible to remember the personal progression and performance of each particular student and the problems (s)he encounters. But in a massive

environment, it is almost impossible for the teacher to retain all this information. For this reason, in massive environments it is important to provide the teacher with a tool with updated information about the students' performance and problems that facilitates personal scaffolding. Additionally, the tool provides the teacher with information about the identity of the students, showing their names and photographies. This facilitates a personalised relation, which is more difficult to achieve as the number of students increases.

2. The **time and space awareness** in the teacher interface. As the time of the session is limited, it is critical for the teacher to be aware of the time devoted to the interventions in order to be able to help the massive number of students in a more fair way. It is also important to be aware of the position of the students in the classroom in order to better plan the interventions to execute, taking into account these positions.
3. A user **interface that guides** the student through the intended workflow. The interface to ask a new question guides the student in the process, bringing them to the questions and answers forum to check if the question has been already posed and/or answered; otherwise they can add a new question. This mechanism avoids duplicated questions and maximises the social interaction between peer students.
4. **Social ratings** in the questions and answers forum. In a massive environment with hundreds of students in the same physical room, it is very difficult to detect which questions are more important, or shared by several students in different locations of the room. Allowing students to join their peers' questions, and to rate such questions and answers helps to identify the relevant doubts and the ones shared by many students, as well as the answers that respond better a question. These ratings are also shown in the student interface, and the relevant content bubbles up so that it is located on the top part. Besides that, the usage of these curated questions and answers also helps the teacher to find common problems and adapt the course materials for further usage.
5. A **scalable architecture**. The technology behind classON (as seen in Figure 2) has been selected to permit scalability. For example, for the communication of learning events in real time among participants we make use of websockets[2] and nodejs[3], which enable to scale the number of users to hundreds (at least). Besides that, we use a non-relational (also called NoSQL) database, mongodb[4], that allows storing the learning events and other parameters during the session in a scalable way.

But there are also some features that are not compatible with a massive environment, and need an adaptation of the interface or even some re-implementation for that purpose.

---

[2] http://www.websockets.org/

[3] http://nodejs.org/

[4] http://www.mongodb.org/

- The teacher interface has been designed for a computer lab setting. Thus, it shows the photos of the students as a way for the teacher to get to know them and the end of the semester, and personalise the interactions with them. In a massive environment the information for each student should remain smaller in the main teacher interface to fit the screen size.
- The current implementation of classON has been designed having in mind a scenario with just one teacher per classroom. In a massive environment, the possibility of several teachers collaborating in a learning activity should not be dismissed. Therefore, this lack hinders the possibility of collaboration of several teachers with the same group of students.

As a conclusion of the previous analysis, for a massive environment the tools should possess scalable interfaces. That is, independently of the numbers of students participating in a activity, the teacher should be able to access the students information in a clear and straightforward way. Moreover, a tool suitable for massive courses should allow the collaboration of the different participants in the activity, making scalable the number of each of them. That is, it should enable the participation of an unlimited number of students but the same applies to teachers.

In the next section we describe how these limitations could be overcome with new features, designed using a foreseen massive scenario.

4 Adapting classON for a massive course

As discussed before, there are some limitations that hinder the utilization of classON in a massive course. In this section we are going to describe how these limitations could be overcome in a foreseen scenario. For that purpose, we make use of an adaptation of the [Carrol, 00] methodology to design tools based on scenarios: we have defined a characteristic scenario and used it to extract some conclusions about the utilisation of classON in this scenario for designing new features.

The scenario we have foreseen in order to design new features suitable for massive settings, is a massive face-to-face activity with hundred of students and the usage of the classON system. Regarding the infrastructure, assuming a massive session hinders the computer lab setting because the existing computer classroom infrastructures usually are limited to much fewer students; nevertheless, students' laptops or mobile devices can be an alternative solution. Therefore we assume the face-to-face scenario in a lecture hall with capacity for hundreds of students. Regarding the learning methodology, any teaching strategy that benefits from improving awareness about students' progress and/or doubts, or from improving the (quality of) teacher-student and student-student interactions would apply. For example, a traditional lecture, which benefits from improving the teacher's awareness about the students' knowledge. Nevertheless, some learning methodologies are particularly demanding regarding awareness and interaction. In consequence, they seem particularly suitable for analysing the requirements of a supporting tool. For example, the "flipped classroom" methodology, which arose a few years ago and was popularized by Salman Khan and the Khan Academy[5]. It consists in changing the classroom paradigm: instead of using the face-to-face session for lectures and propose exercises to the students as homework, it suggests the students watch the pre-recorded lectures at home and use the face-to-face session with the teacher to work on exercises and ask questions. Therefore, a flipped classroom is characterized by a great number of interactions, mostly between teacher and students.

Introducing classON in a massive classroom would help teachers and students to execute efficient teacher-student interactions and would promote interactions among students by means of the Q&A forum. The interaction device for the students to indicate progress and questions would be the students' personal laptop or mobile device. The teacher would use a tablet device to monitor the students' status (progress and questions).

This scenario allows us to understand some of the features that should be included in classON to be used in a massive environment

1. **Student interface adapted to a mobile** device. As in a lecture hall the students will be using their personal devices (laptops, tablets, smartphones), the student interface of the classON system should be accessible for even the most restrictive one: a mobile device. Therefore, a scalable application of classON requires its adaptation to mobile devices, maintaining the current use cases: indicate progress in the lecture, and ask for help, including the Q&A forum with all their social capabilities. Being a web-based interface, classON is easily adaptable to this context (in fact, it is ready to use, but the usability should be improved).
2. Teacher interface **adapted to a massive classroom**. To adapt the teacher interface (see Figure 2) for the visualization of a massive number of students by abstracting and simplifying the information. This means not showing the photos of all the students in the main interface; using colours to indicate status and progress to quickly identify students with questions and students with low progression. Personal information is still valuable, though, to facilitate the teacher identifying the students, which also make students feel more engaged. In consequence, the interface should allow the teacher to focus on a region and amplify it to show the details on the students located in it, like using a magnifying glass.
3. Implement **peer learning and tutoring** strategies. A massive open online course forum makes use of the mass of students to foster peer learning. This strategy, which has benefits for the students and at the same time alleviates the teacher from some of the tasks, can also be applied to face-to-face environments. The supporting tool can facilitate its application. For example, a student or group can be recommended to help another automatically (recommended by classON based on the progress and the location in the room) or suggested by the teacher in real time (based on the awareness information provided by the tool).

[5] http://www.khanacademy.org/

5 Features of tools for massive learning environments

This section provides a vision of the characteristics of a tool for a massive face-to-face environment. The main conclusions have been extracted from the analysis of the classON characteristics: those already tested in a real non-massive setting (section 3), and those emerging from a massive scenario (section 4). The result is a set of recommendations in various aspects of the learning activity, always having in mind the restrictions of a face-to-face session for a massive number (hundreds) of students in a space where the students only have access to their personal devices. As explained in the previous section, the underlying pedagogical approach is generic. However, methodologies that require a high number of teacher-student and student-student interactions would benefit most.

We have classified the recommendations according to the stakeholder they address (teacher, student, both) and the technological or pedagogical objective they address in Table 2.

The first recommendation (R1) addresses the issue that, having a massive number of students, the number of interactions among them will be massive too. In these contexts, there is a need of a curation process of the most relevant interactions for the community. As the number of interactions is massive, the curation process cannot be carried out by the teaching staff and this responsibility should be delegated to the students as they do have a massive power of action. As a result, a tool for a massive face-to-face environment should **provide mechanisms for the students to interact and curate the interactions for the most relevant ones to bubble up for newcomers**. The second recommendation (R2) is related to guiding the students in the interaction to their peers and the teacher. The **interface of a system in a massive environment should scaffold their interactions** in a way that they interact with their peers first, and if this interaction is not fruitful, then ask for an interaction with the teacher. The context of R3 is a face-to-face session for a massive number of students in a lecture hall where they can use only their personal devices. Therefore, if they have to use their personal devices it is recommended that the designed tool has a **mobile web version**, more likely to be accessible in their personal devices.

R4 highlights **the importance of time and space awareness for the teacher in a massive environment**. Because of the time constraints of the face-to-face sessions, the teacher has to be aware of how his/her time is used and the information about the students contextualized in the space, in order to make more efficient interactions. This is also related to R5, as the **information about the students' status** (progress, questions or whatever could be relevant for the teacher) should be very handy, again to make the most out of the time in the session. The sixth recommendation (R6) is related to **the importance of a simple and straightforward interface** for the teacher that offers him/her the previously mentioned information (time, space, students' status) in a meaningful way. One way to make it simple (and quickly accessible) is to use colours to code the different student information.

R7 is the most technical one and is related to the architecture of the application itself. If the application should be used by hundreds of students in real time, the technologies chosen and the implementation should be **scalable enough to make it work fluently under these massive constraints**. Finally, the eighth recommendation (R8) is very related to the first one and defines that as well as curating the massive number of interactions, the interactions themselves could be planned (automatically or by the teacher) in order to **foster peer learning**. This strategy benefits the students in the interaction as well as the teacher because it alleviates him/her from doing this work and could be committed to help other students.

This set of recommendations is useful for practitioners designing a new tool or adapting an existing one for a massive face-to-face environment. Therefore, the practitioners will face the awareness and interaction problems described in this article and, consequently, will be handy for them to have this set of recommendations while creating or adapting awareness tools. It could be used as a guide or as a checklist for designing this kind of systems or tools, or just to get some inspiration on how a real-world tool has been designed. But in any way pretends to be an exhaustive list of features applicable for all type of tools in massive settings.

Id	**Definition**	**Stakeholder**	**Objective**
R1	Social interaction and curation	Student	Pedagogical
R2	Interface guiding the workflow	Student	Pedagogical/ Technological
R3	Mobile web version of the app	Student	Technological
R4	Time and space awareness	Teacher	Pedagogical
R5	Student info awareness	Teacher	Pedagogical
R6	Simple color-coded interface	Teacher	Technological
R7	Scalable architecture	Both	Technological
R8	Peer learning	Both	Pedagogical

Table 2: Recommendations for awareness-based tools to be used in a massive face-to-face environment

Finally, some of these results can be extended to online (instead of face-to-face) massive settings, such as MOOCs. The recommendations regarding social interaction and curation of content by students (R1), interface guiding the workflow (R2), scalable architecture (R7) and peer learning (R8) are totally applicable to MOOCs, in fact they have been implemented in the most popular MOOC platforms. Regarding student info awareness (R5) and simple color-coded interface (R6), they are also present in the teacher's version of the platform. Mobile version of the app (R3) has not been implemented by MOOC platforms but we foresee an imminent implementation, since in our opinion it is totally applicable to online learning. Finally, time and space awareness (R4) constitutes the main difference between online and face-to-face environments and needs further adaptation to apply to MOOCs.

6 Conclusions and future work

In this work, we have discussed the usage of awareness tools in massive face-to-face learning settings. We have described the difficulties students and teachers face in these contexts, mostly derived from pedagogical aspects and from their massive characteristics. With that in mind, we have reviewed current solutions that address such problems, with tools designed for massive environments and awareness tools used in more reduced ones. After that, we perform an in depth study of an awareness tool, classON, analyzing its suitability for massive courses, as well as foreseen requirements to adapt it to these kind of contexts, based on the experimental results obtained so far in more reduced environments. Based on that analysis we have obtained a set of recommendations and good practices for tools used in massive face-to-face environments. They are addressed to designers of learning tools to be used in a massive face-to-face environment. We have also provided some insights on how these recommendations apply to massive online courses, and thus they are also useful for online learning practitioners. These contributions are founded on the design based on scenarios methodology. Experimental testing, in a real massive setting, is still needed and planned as future work to further validate these conclusions.

As future work, we have planned to implement some of the envisioned features of classON and test the tool in an authentic massive face-to-face setting. On the other hand, in order to validate the set of recommendations provided in Section 5, we will use them to adapt tools used in reduced environments to massive ones and report on the result. Moreover, we foresee that some of the recommendations could be also applicable to online courses (MOOCs) and we will also further explore this topic.

Acknowledgements

Partial support has been received from the EEE project (TIN2011-28308-C03-01), funded by Spanish *Plan Nacional de I+D+I*, and the eMadrid Excellence Network, funded by the Madrid Regional Government (Comunidad de Madrid) with grant No. S2009/TIC-165.

References

[Alavi et al., 09] Alavi, H. S., Dillenbourg, P., & Kaplan, F. Distributed awareness for class orchestration. Learning in the Synergy of Multiple Disciplines – Proceedings of the 4th European Conference on Technology Enhanced Learning (pp. 211–225), 2009. Springer.

[Carrol, 00] Carroll, J. M. Five reasons for scenario-based design. *Interacting with Computers*, *13*(1), 2000, 43–60. doi:10.1016/S0953-5438(00)00023-0

[Conole and Alevizou, 10] Conole G., and Alevizou P. "A literature review of the use of Web 2.0 tools in Higher Education". A report commissioned by the Higher Education Academy, 2010.

[Crouch and Mazur, 01] Crouch, C. H., & Mazur, E. Peer Instruction: Ten years of experience and results. *American Journal of Physics, 2001 , 69*(9), 970. doi:10.1119/1.1374249

[Ebner, 11] Ebner, M. Is Twitter a Tool for Mass-Education? *4th International Conference on Student Mobility and ICT*, Vienna, 2011.

[Gutiérrez et al., 11] Gutiérrez Rojas, I., Crespo García, R., & Delgado Kloos, C. Orchestration and Feedback in Lab Sessions: Improvements in Quick Feedback Provision. In *Proceedings of the 6th European Conference of Technology Enhanced Learning (EC-TEL 2011), September 2011 Palermo, Italy* (Vol. 6964, pp. 424–429). doi:10.1007/978-3-642-23985-4

[Gutiérrez et al., 12] Gutiérrez Rojas, I., Crespo García, R. M., & Delgado Kloos, C. Enhancing orchestration of lab sessions by means of awareness mechanisms. EC-TEL 2012: 21st century learning for 21st century skills: 7th European Conference of Technology Enhanced Learning, 18-21 September 2012, Saarbrücken (Germany) (Vol. 7563, pp. 113–125).

[Mayer et al., 09] Mayer, R. E., Stull, A., DeLeeuw, K., Almeroth, K., Bimber, B., Chun, D., & Zhang, H. Clickers in college classrooms: Fostering learning with questioning methods in large lecture classes. Contemporary Educational Psychology, 2009, 34(1), 51-57.

[Novak et al., 98] Novak, G. M., Patterson, E. T., Gavrin, A., & Enger, R. C. Just-in-Time Teaching: Active learner pedagogy with WWW. In *IASTED International Conference on Computers and Advanced Technology in Education, 1998* (pp. 27-30).

[Pohl et al., 12] Pohl, A., Bry, F., Schwarz, J., & Gottstein, M. Sensing the classroom: Improving awareness and self-awareness of students in Backstage. In Interactive Collaborative Learning (ICL), 2012 15th International Conference on (pp. 1-8). IEEE.

[Reinhardt et al., 12] Reinhardt, W., Sievers, M., Magenheim, J., Kundisch, D., Herrmann, P., Beutner, M., & Zoyke, A. PINGO: peer instruction for very large groups. In 21st Century Learning for 21st Century Skills, 2012 (pp. 507-512). Springer Berlin Heidelberg.

[Yardi, 08] Yardi, S. “Whispers in the Classroom." Digital Youth, Innovation, and the Unexpected. Edited by Tara McPherson. The John D. and Catherine T. MacArthur Foundation Series on Digital Media and Learning. Cambridge, MA: The MIT Press, 2008. 143–164.

[Zarraonandia et al., 13] Zarraonandia, T., Aedo, I., Díaz, P., & Montero, A. An augmented lecture feedback system to support learner and teacher communication. British Journal of Educational Technology, 44(4), 2013, 616–628. doi:10.1111/bjet.12047