Web-based Audience Response System Using the Educational Platform Called BeA

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Currently Audience Response Systems (ARS) can easily be used in classes enabling students to participate in questionnaires and polls. The literature about ARSs shows their benefits, highlighting as the most important the student engagement and classroom attendance. Several companies provide solutions to support ARS functionalities by using dedicated systems (e.g. remote control devices and dedicated receivers) or more generally available web technologies. In this paper, we review web-based solutions and introduce our own ARS development. We have created a web-based system that enables students to answer in-class questions using their own devices. This system can be operated from devices running a web browser (e.g. laptop, tablet or smart phone). Our approach allows poll creation and management through web interfaces and it is focused on two of the main needs that are not covered by other services. The first need is to facilitate students’ access and the second is to provide more question types.

ACM Classification: K.3.1

Keywords: audience response system; formative learning; in-class participation; learning platform; educational technology

1. Introduction

Teachers use several techniques and methodologies to improve their class performance. One of the main goals to improve learning is to achieve better student engagement. One technique used to analyse class knowledge is based on making in-class questions. When students must answer these questions using a hand raising method, they are under the pressure of responding in front of their teacher and their peers. For this reason, they usually do not answer what they really think or they even refuse to participate because they fear what their peers or the teacher might say. This behaviour is reduced by the use of Audience Response Systems (ARS).

ARSSs allow teachers to ask questions to students electronically during the classroom time in an anonymous way. The basic operation of this kind of system is based on the distribution of remote control devices among students. Students using these devices can answer the questions and the system collects the responses, which offers anonymity reducing students’ stage fright. The questions are shown to students using a video projector, and the results are collected and processed, being presented to the students as a graph or as a spreadsheet. Normally, the system...
revolves around the teacher’s computer. Thus, the teacher has direct access to the results and can modify the course of the class according to the data collected.

Although this technology is being used in many educational institutions, purchasing an ARS system is neither free nor trivial. The main problem is the cost involved in hiring and maintaining the service. In the worst case scenario, institution managers have to purchase as many remote control devices as the number of students attending classes and in this way they must manage a large number of receivers. It is therefore understandable that the use of these systems, which have been successfully tested in several scenarios, is not part of the daily life of many educators.

Fortunately, new technologies have become cheaper over time. Currently, it is common to use mobile devices with internet access and native web browser applications. This way, people can access web pages using smartphones, tablet PCs, laptops, etc. For this reason, some companies are developing ARS over the web. This approach allows users to participate using their own mobile device or computer.

We wanted to test these technologies in actual classes due to the lower prices of purchasing new voting systems. We have been reviewing some commercial web-based ARS services looking for one that would fit our needs. As noted below, tested services neither allowed us to make the kinds of questions we wanted nor enabled us to shape texts the way we needed (i.e. coloured and indented programming code). In this paper we present the information obtained from commercial services. As a research team we have some previous experiences developing and testing educational web applications, so we decided to create our own web-based ARS. In the next sections, we explain the team’s experience in creating web applications oriented to questionnaires and our last work designing a functional prototype of a web-based ARS. This prototype was developed to cover some deficiencies found in commercial services and was tested in an actual class.

The paper is organized as follows. Section 2 presents a brief state of the art about ARS and commercial services available that are similar to our development. The section explains the different approaches indicating the main features of each one. Section 3 summarizes our previous experience in the creation of an ARS system within the Pi2E project boundary (Llamas-Nistal et al, 2012b). Section 4 presents the voting system created for our educational web platform used at the University of Vigo, called BeA (Llamas-Nistal et al, 2012a). This section explains how the voting is done, how users access the forms, the types of surveys that are allowed and the experience carried out in a real context. Finally, in Section 5 we present our conclusions.

2. State of Art

This section shows the state of the art of ARS distinguishing between traditional and new solutions. The new technologies have introduced a lot of advantages in the use of these systems in the classroom by teachers. General problems and benefits have been well documented in existing literature and they are analyzed in relation to the traditional solutions. The second part of this section is mainly focused in the opportunities and functionalities offered by the very recent systems.

A. Traditional ARS

Traditionally, the basic operation of ARS is based on the distribution of remote controls, called “clickers” or “zappers”, to the students. With these handheld devices, each student in the class can answer the questions asked by the teacher. Questions are usually presented to students on a projection screen. Each student can think over the question and answer it using the remote device.
A receiver is used to capture students’ responses. This receiver is typically connected to a computer that processes the answers and produces a visual representation of the results allowing the speaker (and the students) to review them in real time. Presently, these systems use wireless communication links in the form of radiofrequency (RF) signals. Older systems were based on infrared (IR) communications, but they usually experienced interference from lights or other IR transmitters.

This kind of ARS has been widely used in educational settings and there is much literature about their educational benefits (Fies and Marshall, 2006; Kay and Lesage, 2009; Draper and Brown, 2004) and practices (Beatty et al, 2006; Mayer et al, 2009). This kind of technology is used in many teaching scenarios (Caldwell, 2007). Following are a few examples:

- To increase or manage interaction though questions to start a discussion or to collect votes after a debate or a class.
- Assess students by asking questions about homework or reading tasks.
- Polling students’ opinions or attitudes.
- Make quizzes or tests.

Students increase their participation by not having to orally respond before their peers. According to the literature, students attend more lectures and their alertness is higher than in conventional sessions. In addition, students can compare their answers with their peers involving themselves in a very fruitful reflective process and promoting their involvement through competitiveness. Meanwhile, teachers can test students’ knowledge and vary the lesson plan or discourse to shape the needs or issues identified from the learners’ answers. Another option for teachers is to involve students in discussion to search for a common solution or explain why they choose one option or another. In addition, teachers can prepare and focus their lectures to case-based instructions. In these scenarios, the inquiring environment promotes students’ participation and problem-solving capabilities. In general, this interaction improves the quality of the students’ learning and students also make a greater commitment, improving their classroom attendance and engagement.

It is common for traditional ARS to separate the task of displaying the question/answers and the task of capturing the students’ answers and extracting the data. On the one hand, questions and possible answers displaying often falls on the teacher’s shoulders, which have to include questions within a presentation to show them to the students. The remote controls do not have any function to display any kind of information. On the other hand, teachers can monitor the polling activity and results using a personal device (a computer application) that controls the receiver. In some cases, the ARS provides a desktop application that enables the teacher to control the poll and display the statistical results. For example, the service offered by iClicker (2012a) allows teachers to install a software application that controls the polling and the display of the result data on the computer screen. This application, when used, is shown over any other applications that are displayed on the computer. Thus, the results are directly displayed over the presentation slides.

The use of “clickers” allows both anonymous and authenticated participation. To achieve an authenticated participation a registration process must be made, where a link between a physical device and a specific user is established. Using the authentication in educational settings, teachers can identify student answers and control their evolution during the lectures. Furthermore, segmented statistics can be made up (e.g. results by age, sex). The use of registered devices means that users cannot share devices to participate in surveys. The process of linking a control to its owner is usually quite complicated and time consuming. Students are forced to contact the company or teachers must make an initial effort to create a table with all the information.
Kay et al (2009) identifies some drawbacks related to the use of dedicated remotes. We highlight the following ones:

- Students must bring their remotes to class and it is not always possible to ensure their proper functioning (e.g. poor maintenance).
- The student may not participate in voting if s/he forgets to bring the remote device to class.
- Participation is also difficult in case of breakage or malfunction of the device.
- The use of dedicated controls puts up the final price of the system.

In addition, remote devices are usually quite simple, reducing the possible question types to multiple-choice where the students select one of the possible answers. In case teachers want to perform more complex questions, more advanced devices are needed. These devices generally have a greater variety of buttons (i.e. alphanumeric and function buttons) and, in some cases, an LCD display (Barber, 2007). Nevertheless, the quality of LCD screens is often quite low, having mostly a presentation based on 7-segment displays. Another factor to consider is that the remote controls and receivers from different companies cannot interact with each other. For this reason, a single user that participates in surveys using different services will have to handle multiple devices.

B. New ARS

During the last two years numerous systems have been developed supporting ARS functionality. In many cases these new systems have been developed taking into account their use by teachers in educational settings. Table 1 shows the more relevant ones and provides a comparison of their main features.

As a key difference with traditional solutions, new ARS are based on the use of generic devices instead of proprietary remote controls. The advantages of this approach are quite evident as long as traditional ARS companies are starting to offer the chance to participate in polls using this kind of general-purpose devices. The generic devices are mobile phones with the SMS service, or smartphones, tablets or computers with proprietary applications (e.g. Android or iOS) or a general Web application:

- Companies allowing participation by SMS are: Poll Everywhere (2012), Top Hat Monocle (2012), Shakespeak (2012) and SMSpoll (2012), among others. Using this solution, each time users want to participate in a survey, they have to send a SMS to a particular phone number using a specific code that identifies the question and the desired answer. This method can be useful for occasional surveys, but in other cases it can result in expensive phone invoices.
- The use of proprietary application is supported by: Clicker School (2012), Turning Technologies (2012) and Socrative (2012). These applications are platform dependent and use the purchased data rate for the device or a Wi-Fi connection to send the answers via internet. In this way, the cost of participation can be considerably reduced.
- Solutions that use internet to send the student responses follow a complete web-based model (e.g. Ayu et al, 2009 and all the services described in Table 1). In this case, students will use a web browser to connect to the poll and answer the questions. In some systems a widget is provided to facilitate the introduction of the ARS in any Web page.

Focusing on web-based ARS, teachers must use a web browser to create polls as shown in Figure 1.A. Teachers control the polling system and display the question and possible options using the
same approach (cf. Figure 1.B). Some services offer a Powerpoint embedded solution, inserting a Flash object or a Visual Basic application from which teachers can show the questions, display statistics and control the visibility of the polls (e.g. Poll Everywhere, 2012; SMSPoll, 2012).

The answering system used for web-based responses varies from one service to another, but we found two common patterns. In some cases both patterns are offered by the same service (e.g. Poll Everywhere, 2012). These patterns are described as follows:

Table 1: Comparison of ARS services
The first one is based on the use of a single web page with a general form for all the active surveys at the same time. Each possible answer is assigned an alphanumerical key-code, identifying both the question and the answer. Students must insert this key-code into the web form to indicate the answer. This web form is unique for all users regardless of the session in which they are involved (cf. Figure 1.D). Therefore, no information about the question and available options is provided. In addition, if a user enters a wrong code s/he could be participating in another survey or answering a different question.

The second pattern involves a web space where users can participate and view statistics related to a particular polling session. Services such as Poll Everywhere (2012), Clicker School (2012), Maya (2012), Top Hat Monocle (2012) and Socrative (2012) follow this kind of pattern (see Figure 1.C). In this case, users have on their devices a complete display of the question without the limitation of using alphanumerical codes or depending on a shared screen.

About the question types, most ARS solutions support just two types: the multi-choice question and short text entry questions. Although the web platform can allow more elaborate question types, services are focused almost exclusively on these two options. Socrative (2012) offers some different types: the “paced quiz” and the “space quiz”. A “paced quiz” is a quiz composed of more than one question, but only one question is displayed at a time. The questions are displayed at a particular pace making two kinds of control possible: “teacher paced” or “student paced”. The former is controlled by the teacher, selecting when students are able to answer the questions. When using the latter, the students can decide when they answer each question. A “space quiz” is
composed of several questions and the students can race to answer questions before others do. Another service that offers a different type of question is Big Nerd Ranch, which allows the students to submit drawings as a response.

The new ARS platforms do not involve a dedicated receiver. Instead a (web) server is used to capture and process learners’ responses. This server can be used in parallel in more than one polling session and in this way several teachers can share the server capabilities without mixing data. In addition, results are stored in the server.

Despite all the previous advantages, new web-based ARSs have three main disadvantages with respect to traditional systems:

- The need of an internet connection and a portable device with a web browser application. This is essential to work with these types of ARS, so both teachers and students must have an internet connection. The second is also a main issue as long as not everyone owns an appropriate device. The number of students with smartphones, tablets or laptops in the classroom is high and increasing, but the average is far from 100%. Moreover, in some cases teachers are not willing to let their students use these kinds of devices during lectures.

- Access control and user access. The access control is a special issue because web is accessible for anyone from anywhere. If teachers want to limit the students participating in a poll, they must control which person is allowed to get access. This can be managed by requiring a registration before the poll starts. This registration is very similar to any other registration in typical web-based systems. Another problem is that teachers cannot control where the participants, either anonymous or registered, are accessing from. Traditional ARS do not have this problem because of the space limitations inherited from the wired IR and RF communications. We have found just one service supporting space restrictions (i.e. Big Nerd Ranch, 2012). This service allows teachers to make polls over a Wireless Local Area Network (WLAN), usually using a Wi-Fi Access Point (AP). The teachers must run software that works as a web-server over the WLAN and participants must connect their devices to the same WLAN and access the teacher’s device.

- The last drawback is about how users access the service. Internet-based solutions can be accessed from web browsers, from dedicated software applications or using both approaches. Services with a web page frontend may be accessed from different types of devices with support for web browsers (i.e. personal computers, netbooks, smartphones and tablet pcs). In these cases, students must type a particular uniform resource locator (URL) to access the poll. The URL can be difficult to write, leading students to mistype it. This problem will no longer occur as students get used to accessing the service or if a dedicated software application is used. Still, this issue is critical when dealing with sporadic polls or the first few times teachers use these services. This can be an annoying experience for students and it can cause an initial negative impression. It is important to notice that this issue is not present in traditional ARS and none of the services investigated addressed this problem.

3. ARS in Pi2E

We have previous experience in the development of an ARS solution in the context of the Pi2E project (González-Tato et al, 2012). This project was focused on providing an e-learning system over iGoogle (Google, 2012a). The iGoogle page allows a user to compose his/her own personalized web page using gadgets and RSS readers. Within this framework, we developed a set of educational
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OpenSocial gadgets (OpenSocial, 2012), both for teachers and students, trying to support their educational activities from the personal iGoogle page, which could involve the performance of some activity such as answering a questionnaire.

We extended some gadgets and developed a new specific one called Edu-GAR (Llamas-Nistal et al., 2012b) to support ARS functionality in Pi2E. Using these gadgets, teachers can create and control the questions they want to ask students during a presentation, and the students can answer these questions. The Edu-GAR gadget replaced the use of dedicated remote controls allowing the participation of students using their personal iGoogle pages.

Unlike common ARS services, the Pi2E questionnaires may involve one or more questions. In addition, conventional systems are limited to choice questions or text input, while this system allows the creation of more elaborate question types (e.g. sort, inline choice). For testing this system, an experimental link was created between Pi2E and an educational platform used in our university, called BeA (Llamas-Nistal, 2012a). The profile of the students was modified so they could use their iGoogle identifier to get access into BeA. This modification was made to identify the communication with the gadgets. The authentication system prevents students from registering (i.e. enter their credentials on the gadget) every time they want to use the gadgets. Students, once registered in the platform, could use the gadget Edu-GAR for in-class participation.

Although, this approach offers certain advantages to users, it presented important drawbacks in practice. The main issue for students was the lack of awareness of the iGoogle platform. Participants must bring their iGoogle pages configured before class participation. This takes away spontaneity and forces the teacher to instruct their students in the use of the site. Moreover, given the nature of the subject, we were not able to identify all the students the first day of class and register them on the platform at the beginning of the session. For this reason, explanations had to be repeated as students enrolled. Another key drawback for this project was the announcement of the closure of iGoogle scheduled for November 1, 2013 (Google, 2012b).

4. ARS in BeA

After our previous experience, we decided on the development of an ARS directly in BeA (Llamas-Nistal et al., 2012a). BeA is a web platform used in the University of Vigo. This platform is oriented to the management of educational courses. Teachers using this platform can manage students and their examinations. We decided to create a web-based ARS over this platform. We want users to access our service through an internet connection. Users can use a conventional internet connection or a mobile network. In this way, users are able to use the device they like to access the poll (i.e. smartphones, tablets or computers). Users need a device with a web browser and access to the internet. Students will use a web form hosted in the BeA to participate in polls. This web form was developed taking into account its display on mobile devices and the constraints of these devices (cf. Figure 2). We created the web form using HTML, CSS and JavaScript. This web form maintains communi-
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cation with the server using Ajax and sending JSON messages. The JSON messages are received by the JavaScript libraries and shaped using HTML and CSS to display the information to the users. The ARS in BeA offers certain features not present in other ARS solutions. The next sections present the main features and details the process for displaying polls to students.

A. Questionnaires

The BeA ARS enable teachers to use questionnaires including questions from different types, based on the IMS QTI interaction types (IMS, 2012). The question types are classified into simple interaction questions and text-based interactions. The simple interaction questions are focused on the interaction with a number of options that users combine to create the response. The following sub-types are supported:

- Choice interaction: the common multi-choice question type.
- Match interaction: users must create option pairs as response.
- Associate interaction: users must create an option group of two or more options as response.
- Order interaction: users must order the options according to the question.
- Gap-match interaction: question heading has some gaps inside it. Users must fill those gaps with one of the global options. The global options are common for all the gaps in the question and one option may be selected for several gaps.

In the text-based interaction questions the student must enter some text or interact with a piece of text to provide the answer. The following sub-types are supported:

- Inline choice interaction: question heading has a set of options inside it where the user must select one of them. There can be multiple sets inside a single heading. Each set has its particular options.
- Text entry interaction: question heading has a set of editable gaps. Users can type the answer in those gaps. A single question may have several gaps.
- Extended text interaction: users can write whatever they want as response (similar to the short questions available in existing ARS).
- Hot text interaction: question heading has a set of selectable pieces of text inside it and the users must select one or more of them.

In addition to the several types of questions the questionnaires allow some customization related to their delivery. Teachers can choose if a survey is public or private. In case of public surveys anyone can participate. In case of private surveys only registered students can access. Teachers have several configuration options to show the questions to the students: (a) shuffle questions; (b) shuffle options inside questions; (c) allow participants to see their own response; (d) allow participants to change their answer; and (e) allow participants to respond more than once.

B. The Polling System

The system includes a control panel to publish, hide and view the questionnaires, the questions, the statistical results and the individual responses. Using this control panel a teacher can always control which question is shown. In a normal poll process, all questions of the session will be hidden at the beginning and students will be able to answer when the teacher decides to activate each question (teacher-pace).
Students must connect to a specific URL to participate in a poll. As we commented above, forcing participants to write a full URL, especially when it is a tricky one or in a smartphone, can take some time and be annoying. To reduce the impact of this problem, a QR code is automatically generated containing the right URL to access the poll (cf. Figure 3). Participants can use their mobile devices to capture the QR code and get instant access to the poll. There are several free applications able to read QR codes and access a web address with just one click (e.g. Barcode Scanner for Android developed by Zxing Team or QR Reader for iOS developed by TapMedia Ltd). These applications are very common in current smartphones and users can manage them in a very useful way.

The complete operation of the system is as follows (cf. Figure 4):

- First (cf. Figure 4.A), the teacher initiates the system and provides the URL (and corresponding QR code) to the students. This can be done using the classroom projection screen. Then students load the URL in their devices using any QR reader application and get access to the poll session. At this time the system will not display any question.

- When the teacher activates a question its content and the possible answers will be shown in the teacher computer screen (cf. Figure 4.B). This interface also includes the number of people that accessed the question, the number of responses received and a graphic showing the statistical results (depending on the question type, individual answers can also be shown). If the teacher computer is connected to the classroom projection screen the entire class will be able to see the question and answers.

- At this time (cf. Figure 4.C) students can refresh their web form (i.e. from the refresh button or fully recharging the web page) and the question including the available options will be displayed in their devices. In this way, students do not need to read the question from the classroom screen, but they see all the content in their own device. Notice that information related to the number of people and answers received is not shown. Then students should provide their answers.

- When the teacher decides or when time is over (cf. Figure 4.D), the poll is closed. During the time the poll is active, the students’ responses are collected. The number of people who accessed, the number of responses received, the statistical results and the particular results are updated dynamically as soon as they are received.
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C. Hands-on Experience

The BeA ARS functionality has been experienced in practical sessions of the Programming II subject during the first semester of the 2012–13 academic year. This subject is included in the second year of the studies on Grao en Enxeñería de Tecnoloxías de Telecomunicación of the University of Vigo. The system was just used in practical sessions because computers were available for all students. In this way students without smartphones or tablets were able to participate in polls. The ratio of available smartphones was around 24% (8 of the 33 students).

The system was used for the first class sessions of the new course to ask students about basic computer programming concepts that have been taught in Programming I, subject provided in the
previous academic year. The teacher wanted to test his students, to see what programming knowledge was retained or forgotten during the summer holidays and also as a review of some basic concepts. In previous years the teaching approach was basically the same, but questions were asked directly to the students who were required to raise their hands in order to choose one of a set of possible solutions. Then, some students were asked directly about their chosen option. This academic year we used the BeA ARS including different types of questions: multi-choice with a single true answer; multi-choice with several true answers; and in-line choice interaction. Questions contained Java code, indented and arranged for easy reading. Students did their best remembering past lessons and trying to answer the questions. The teacher could quickly and easily assess the current state of knowledge of their students.

The classroom and students’ experience was very positive from a teaching point of view. The cognitive load of each student was greater than in previous years, as students struggled to respond to the right answer focusing on their own devices and not on the devices of their partners. In the past, many students in the classroom didn’t participate in this question-answer interaction at all. Usually, they waited until other students (generally the same ones) would quickly provide the right answer. In this year’s experience, the teacher explained to us how the students took their time in order to reflect about each question and then provide the answer individually. A consequence of this change was that the teacher needed more classroom time to finish this activity. In any case, he was very satisfied because students were involved in real cognitive thinking. A key issue related to the BeA ARS system was that the absence of any problem related to the reading of the question and of the offered solutions. Students were able to see and analyse all the content clearly on their devices.

After the experience a survey was given to collect the student reactions. They were asked about the usefulness of the QR code, about the usability of each question type and the general system. Another question was included about if they would like to use this system in the future and an open-ended question to offer their opinion about the system freely was included to complete the survey. The results of this survey are shown in Figure 5. Related to the open-ended responses most students note the anonymity feature, the simple operation and the speed in which they are able to check the results.

Figure 5: Students’ compliance rate
Conclusions
Web-based ARS, despite their disadvantages, have two advantages to consider: the possibility of implementing more complex questionnaires and the final price. Web technologies offer a set of powerful tools that can accomplish complex applications available from the cloud. Cloud computing offers services at lower cost, immediate access to resources, parallel processing and encourages innovation (Marston et al., 2011). From the point of view of voting systems, this scenario enables developers to create new types of polls keeping the original approach of traditional systems incorporating new proposals. Socrative (2012) is a clear example of the innovation possibilities in this field with the “paced quizzes”. However, the lack of variety is evident in terms of types of questions. The systems tested are limited to emulate the behaviour of conventional systems, allowing only multi-choice and short text entry.

As pointed out above, internet-based solutions are cheaper than traditional ones, because there is no need to purchase physical devices to start working. Teachers and students can use from the start their personal devices (i.e. smartphones, laptops or tablets) or use other devices present in classrooms (e.g. computers). Moreover, the same features (i.e. question displaying, full text editing and poll variety) implemented in a traditional system could lead to a substantial increase in the price of the devices.

The creation of dedicated voting applications for each operating system would facilitate the presentation of content by allowing the display of information according to the configuration of the device (e.g. mobile phone). Given the variety of operating systems and devices, the effort would be very great and time-consuming. We decided to offer a greater variety of questions and shape the overall behaviour to facilitate the user interaction. This web approach covers a wide range of devices. Moreover, this solution also reduces the overall cost of service as it is no longer required to purchase dedicated devices. But, this approach needs a special effort avoiding the devices’ layout differences in order to have the same screen distribution regardless of the device used.

The designed prototype is intended to cover some of the disadvantages presented in current systems. The access control can be achieved by linking polls to a particular subject and allowing only responses from enrolled students. From our point of view, the use of QR codes to access the participation forms eases students’ responsibility of accessing the correct poll. This system also prevents students from typing the URL address in the web browser. This will reduce the effect of mistyping and time spent on accessing the participation form. This feature provides faster interaction between students and teachers.

Acknowledgement
We thank Galician Regional Government for its partial support to this work under grant R2014/049 “Research Networks: TELGalia”. We also thank the Spanish Ministry of Science and Innovation for its partial support to this work under grant “Methodologies, Architectures and Standards for adaptative and accessible e-learning (Adapt2Learn)” (TIN2010-21735-C02-01). Last but not least, thanks to J. Lessoff for proofreading this paper for English.

References
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