Yactul: An Extensible Game-Based Student Response Framework for Active Learning

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Abstract

Student response systems as an active learning strategy have shown to be useful in different study domains. With the advent of gamification, these environments have become very popular to improve student engagement. However, existing solutions only provide a static set of activity types and limit their use to classrooms. In this paper, we present Yactul, an extensible game-based student response framework for active learning. Our ecosystem fosters continuous learning both in the collaborative setting of the classroom and the private study environment of the student. Our modular architecture enables a seamless integration of activities from a broad and extensible set. In addition, a mobile app for offline learning extends the experience outside the classroom and allows to replay quizzes anywhere and anytime, track the progress of an individual learner and suggest activities on topics that require more studying.

Keywords: Student response systems; gamification; active learning.

Resumen

Sistemas de respuesta de estudiantes como estrategia de aprendizaje activo han demostrado su utilidad en diferentes dominios de estudio. Con la llegada de la gamificación, esos ambientes se volvieron populares para estimular la participación de estudiantes. Sin embargo, soluciones existentes ofrecen una colección estática de tipos de actividades y limitan su uso dentro del aula. En este artículo presentamos Yactul, un entorno extensible de respuesta de estudiantes para aprendizaje activo a través de elementos de juego. Nuestro ecosistema fomenta el aprendizaje continuo tanto en el contexto colaborativo del aula como en el ambiente de estudio privado del estudiante. Nuestra arquitectura modular facilita la integración de tipos de actividades de una amplia colección extensible. Además, una aplicación móvil para el aprendizaje off-line extiende la experiencia fuera del aula y permite volver a jugar las actividades, dondequiera y cuandoquiera, seguir el progreso del estudiante individual y proponer actividades en cuanto a temas que necesitan más estudio.

Palabras clave: Sistemas de respuesta de estudiantes; gamificación; aprendizaje activo.

1   Introduction

Born into a world of fast evolving technology, millennials are reported to be less tolerant towards classical lecture-style dissemination of knowledge [1]. The consequence of a reduced attention span is often low performance in assessment. In fact, Freeman reported that, at least in STEM (science, technology, engineering and mathematics) classes, students confronted to traditional lecturing were 1.5 times more likely to fail the class than those facing an active learning environment [2]. Active learning is an umbrella term for instructional strategies aiming at fostering student engagement in the learning process [3]. With the advent of the *flipped classroom* approach, active learning methods have been used by teachers during lecture slots in order to improve participation, engagement and, ultimately, assessment performance [1].

Among other strategies, *student response systems* (SRS), also known as *classroom response systems* (CRS) have been used for a few decades [4]. Activities, such as multiple-choice quiz questions on the course content, are presented to students on a projector screen. In the early days, students were given handheld devices known as *clickers* to participate in these activities by pressing a button related to an answer. These hardware-based SRS have become obsolete since the advent of the *bring your own device* (BYOD) philosophy [4]. The fact that students are bringing their smartphones and tablets to the classroom open new opportunities for SRS, which are no more limited to answering only multiple-choice questions, but may also engage in other types of activities.

Studies have shown that SRS can improve a variety of learning outcomes in STEM education [5], but also classes in other domains like psychology were positively impacted. According to Fortner, a higher student engagement, better evaluation results and less absences in lecture slots were observed while using SRS in both undergraduate and graduate courses [6]. However, the author also pointed out that the effects of an SRS depend on the learner, the teaching and course characteristics.

Finally, gamification, i.e. the process of introducing game-based elements in non-game contexts [7], allowed SRS to develop beyond answering questions. Morillas stated in a recent study that non-gamified SRS may see a quicker decline in student attendance, engagement and participation [8]. On the other hand, students enjoying a game-based SRS (GSRS) reported a more positive perception with respect to motivation, attention and learning performance than those confronted to a non-gamified SRS. Typically employed game elements are points, leaderboards and time pressure.

However, state-of-the-art GSRS suffer from an issue similar to the one pointed out by De León Cerda [9]. Many learning environments or ecosystems are closed, based on a rigid design and cannot be customized by teachers or students, which have to adapt to the provided environment and its feature set. Existing solutions typically provide a static set of activity types, without the possibility to integrate new, custom game experiences. Apart from game elements like points and leaderboards, the provided activity types are often limited to those of classical, non-gamified SRS.

In addition, current solutions offer limited feedback. While teachers may analyse the results of a quiz in an exported spreadsheet, students can only see their assessment results right after the quiz and share their points on social media. However, their learning progress is not taken into account, as SRS are typically focussed on the activities being played in the classroom. It would be desirable for students to continue playing quizzes at home to review their mistakes, get an overview of topics that need emphasis in their study process and thereby continuously monitor their progress.

In this paper, we present Yactul, an extensible game-based student response framework for active learning. The platform is composed of a lightweight core module responsible for user and quiz management, surrounded by activity-specific modules. These modules can be easily integrated in a plug-and-play fashion. New, custom activity types can thus be added to the platform, in order to respond to institution-, domain- or student-specific needs. A web interface is provided for in-class quizzes.

Beyond the classroom, our ecosystem also includes mobile apps for offline learning, which allow students to replay quizzes at home, track their progress and thereby improve their learning process. In addition to playing the activity sequences from the class, the app can also recommend activities on specific topics the student has answered wrong in the past. This way, a continuous learning experience in the classroom and in the private study environment is provided.

The remainder of this paper is organized as follows. In section 2, we present the state of the art of game-based student response systems. We describe the architecture as well as the classroom tool and mobile apps of Yactul in section 3. We conclude and present ideas for future work in section 4.

2   State of the Art

In this section, we present existing solutions of GSRS. Most of them are commercial solutions, although sometimes backed by research initiatives. All of them are web-based, as this is the most convenient development solution in the heterogeneous context of the BYOD philosophy.

2.1   Web-based GSRS

Kahoot![1] is probably the most popular GSRS platform at the moment. Kahoot! currently supports 4 different types of quizzes. A regular *Quiz* is a sequence of questions with up to 4 answers. Multiple answers can be correct, but only one can be selected by the player. A *Survey* is similar, but there is no correct answer to a question. A *Discussion* is similar to a Survey, but only a single question is presented. The fourth and most recent quiz type is *Jumble*, where a player has to put 4 answers into the right order. In general, a question can be accompanied by an optional descriptive image or video and can be limited in time. The question, answers and remaining time are shown on the teacher's screen which is usually connected to a projector. The student on her device only sees color buttons representing the answers. The solution is shown on all screens once the time has run out. Pauses between questions are possible and can be used by the teacher to provide further explanations on the topic of the passed question in order to rectify any misconceptions. After the quiz, a leaderboard is shown and the teacher can retrieve the class results in a spreadsheet for further analysis. The *Team Mode* makes students gather around a device to discuss the answers and give a single answer per team. Finally, the *Ghost Mode* is available to replay a quiz and compare the current results to the past results of a same student represented then by a ghost player. Note that ghost mode and team mode are, at the time of writing, not yet available for Jumble questions.

Although it is possible to share Kahoot! quizzes publicly and thus reuse entire quizzes by other people, it is not possible to reuse single questions in different quizzes. If a teacher wanted to reuse a single question from a past quiz in another one, she would need to manually retype the question and answers. This could occur when a teacher wants to recapitulate a selection of questions from past week's quiz in order to check the retention of the learned aspects. Apart from the double authoring effort, there would not be a semantic relationship between these two copies, which could be desirable for result analysis afterwards. Apart from the still quite limited set of activity types, it is also not possible to mix different question types in a single quiz. For instance, a quiz cannot contain a multiple-choice question and an ordering question at the same time, as the selection of activity types is made at the creation of a quiz and applies for all contained questions.

Quizizz[2] is similar to Kahoot!, but only allows for a single activity type, namely questions with 2-4 answers, where only one can be correct. Questions can be reused in different quizzes, in opposition to Kahoot! This way, a teacher can easily create a quiz from her own or publicly shared questions and modify them to her needs. Students can see the textual answers also on the screen of their device and can review the whole quiz with their given answers and the solutions at the end of the quiz. In contrast to Kahoot!, it is not possible for teachers to pause between questions, as they are played in an auto-forward mode. Quizizz allows teachers to assign a quiz as homework, which has to be played until a given deadline. This is a first advance in expanding the GSRS experience outside the classroom, although it is not a continuous formative assessment for the individual student yet.

Socrative[3] is another GSRS where students can respond to multiple choice questions, true or false questions or give short textual answers. Socrative does not enable the teacher to set a preconfigured time limit to a question, but she can choose between three delivery methods:

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[1] https://www.getkahoot.com

[2] https://www.quizizz.com

[3] https://www.socrative.com

Instant Feedback, where students have to answer questions in order and cannot change their answers; *Open Navigation*, where students can skip or go back to questions and change their answers; *Teacher Paced*, where the teacher decides about the flow of questions. It is possible to mix different question types in a quiz, but questions cannot easily be reused in other quizzes. A game mode similar to the team mode in Kahoot! is the Space Race, where students can answer in teams and see the progress of their team in form of a spaceship racing towards a finish line.

There are also some non-free products with additional question types, like *Top Hat Monocle* [5] or *Learning Catalytics* by Pearson Higher Education. Latter for instance advertises that students can enter numerical, algebraic, textual, graphical or multiple-choice responses. However, these tools, apart from being non-free, are also closed and thus cannot be extended or customized with custom question types.

All these web-based GSRS provide gamification through points and leaderboards, as well as time pressure, in some way or another. However, they all come with a very limited set of question types. Depending on the study domain, different types of questions could be useful (e.g. pointing at a region on a map in a geography course or collaboratively annotating an anatomy figure in a biology class). In addition, all these systems are closed and cannot be extended with new question types or game modes. Also, running quizzes cannot be modified. Although teachers in some GSRS can pause between questions, it is not easily feasible to skip or replay a question, give more reflexion time or change the order of questions during the game. However, this could be desirable, as the classroom situation might present unpredicted issues which at the design time of a quiz were not obvious to the teacher. Finally, authoring in some GSRS like Kahoot! is made more difficult due to the fact that questions cannot be reused in different quizzes. As Abramson stated, the slow adoption of GSRS in university classrooms is partly due to the time lecturers have to spend in authoring questions [5]. Apart from authoring the very course content, they have to input the quiz questions in a GSRS and would even have to do this multiple times if reusing a question in different quizzes would be desired.

With respect to mobile apps, the Kahoot! app is basically an embedded view of the web interface. This also applies for the Socrative Teacher and Student apps. The Quizizz provides one further functionality than the web interface, namely the ability of "reading aloud" a question and its answers. All these apps are focused on the classroom experience and thus require a stable internet connection. However, it would be desirable to extend the experience from outside the classroom and let the student replay the quizzes as many times as she wants to help her studying a set of topics or just revising course contents. Formative assessment for the individual student based on the quizzes from the classroom, played on her device, is an opportunity to extend GSRS.

2.2 Spaced repetition

In order to foster knowledge retention, there exist applications that apply spaced repetition. Vocabulary learning apps like Memrise are based on the principle of asking a word repeatedly in a growingly less frequent way until it can be assumed it has overcome the forgetting curve. Memrise also comes with different types of questions targeted at language learning (multiple choice, listening, short answers, ...). Flashcard software has also been gamified in recent years. The app Quizlet for instance provides a Gravity game where correct answers have to be given before an asteroid hits your planet. The Match game is used for building pairs of correct vocabulary translations.

3 Yactul

The goal of our work was to build an extensible game-based student response framework. We wanted to combine the best features of existing solutions while overcoming their shortcomings and enabling teachers and developers to extend the platform with new, custom question types to increase student engagement and improve knowledge dissemination, comprehension and

retention. In addition, we wanted to provide a continuous learning experience by allowing the students to take the quizzes outside the classroom and study on their own the proposed activities.

3.1 Continuous Learning

The ecosystem of Yactul is composed of a classroom tool and an offline learning app. The classroom tool runs on a web server and is constituted of different activity-specific modules. Teachers can author activities and play quizzes with their students. In the collaborative setting of the classroom, this enables discussing recently seen topics to deepen the students' understanding of the underlying aspects.

The mobile apps are available for iOS and Android. Their purpose is that individual student can replay quizzes from the classroom at their own pace anywhere, anytime, while still providing gamification elements. The experience is thus not limited to the classroom setting as in many existing solutions, but is extended to the private study environment of a student. Once the activities have been fetched from the server, the app can be used offline, which is particularly convenient if students are outside of a wireless network and without a data plan, e.g. when traveling abroad. The app tracks the student's progress by accounting how well activities have been responded lately. It may also recommend activities that, based on this data, need particular attention in the study process or which have not been treated in a while and might be repeated.

The combination of the collaborative experience between students and the teacher using the classroom tool and the private studying using the offline learning app that enables formative assessment for the individual student provides a continuous learning experience within our ecosystem, as depicted in Fig. 1.
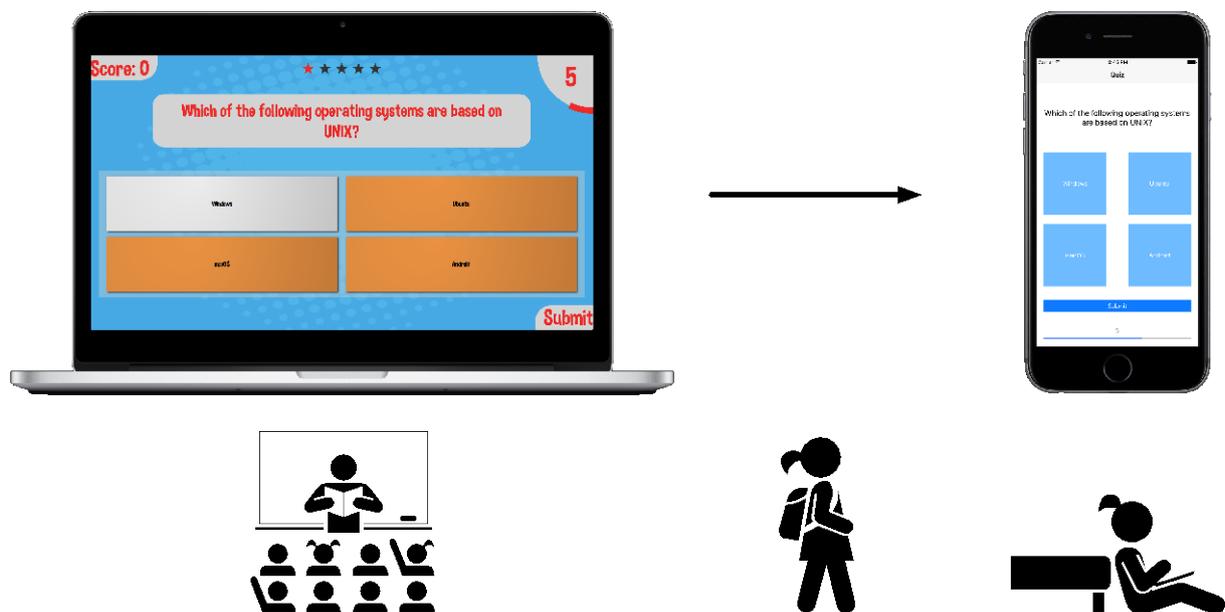

Fig. 1: Continuous learning experience – From the classroom to the private study environment

3.2 Architecture

In Fig. 2, we show the extensible architecture of Yactul. At its center is the lightweight administration component. This core module contains features to administer a Yactul installation, including user (essentially teacher) management and activity management. There exist different types of questions, called activities in Yactul. Each activity is represented by a dedicated module that can easily integrate into the platform by registering at the core module. The core module is generic, in a way that any activity modules respecting a certain architecture and communication interface can be part of the ecosystem, as activity-specific requests are

delegated from the core module to the respective activity-specific module. Each module is responsible for its own data and views. An activity module has to provide different views for the teacher's, the student's and the projector screen. The student can see the question and overall results on the projector screen and answer on the screen of her device. The teacher needs an activity-specific administration view for authoring questions and solutions.

The core module is responsible for delegating requests and data between the different devices and the activity modules. Therefore, a well-defined communication interface needs to be respected by activity developers. Once this is granted, a teacher does not need to configure anything in order to make an activity module work apart from registering it at the core module. The communication protocol is based on REST (Representational State Transfer) web services, which allows the platform to become agnostic of the programming language a specific activity is written in or the location such a module is running at. As quiz-specific data such as user responses are anonymously saved in the core module, the activity modules are completely independent from a specific Yactul installation. While a core module of Yactul could be installed on the server of a Colombian university, it could benefit from different activity modules running in Luxembourg or Canada, which again could be reused in other Yactul installations at other places in the world.
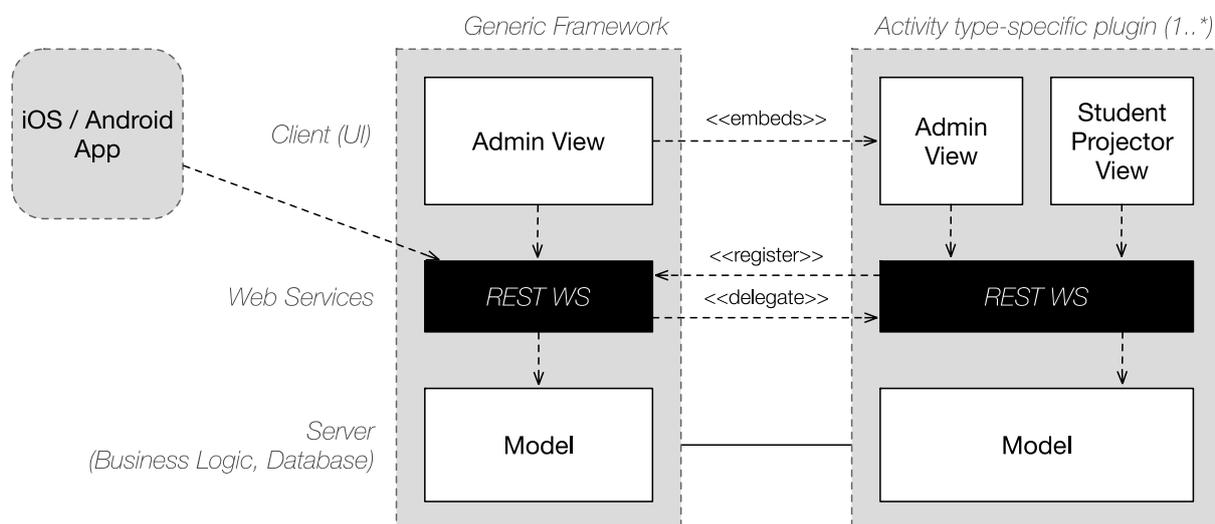

Fig. 2: Extensible Architecture of Yactul

The view layer being based on HTML5, the platform can be used on any modern browser on any type of device. In addition, the user interface follows the responsive design principle, meaning that it adapts to different screen sizes. This is convenient regarding the BYOD approach. The editing interface specific to an activity is embedded in the generic framework's administration interface.

Finally, the mobile apps also communicate with the core module of a Yactul installation by retrieving the quizzes from the server. Apart from this single interaction, the apps can be used offline and independently from the server.

3.3 Activity Types

In the following, we describe the set of activity types we have developed and integrated so far in our ecosystem. Some of them have already been used in state-of-the-art GSRS, but we also designed some new ones to assure a wide variety of games. Due to our extensible architecture, new activity types can be easily integrated in the environment.

A *Simple Question* is a question with multiple alternatives but a single correct answer. Fore- and background images can optionally be provided to further describe a question and enhance the user experience. A countdown is shown to indicate how much time is left to answer the

question. A set of stars indicates the difficulty of the current activity. An answer is submitted either when an alternative is selected or when time is up. An example is shown in Fig. 3. Once the question has been answered by all, the projector screen, as depicted in Fig. 4, shows the correct answer as well as statistics of how many students chose which alternative. This screen varies only little from the one shown on the student's device. Latter screen highlights the selected answer, the correct answer (if differing from the previous one) and the current score of the player.

Fig. 3: Simple Question – Student screen during the answering period

Fig. 4: Simple Question – Projector screen showing the answering results

A *Multiple-Choice Question* is similar to a Simple Question, but there can be several correct answers. The user can check and uncheck her answers until she pushes a Submit button or until automatic submission when time is up. When the solution is revealed, a flashing green

answer on the student screen is a visual cue for a false negative, i.e. an answer that was not selected, but should have been.

Simple Focus is similar to a Simple Question, but the alternatives are shown one at a time in a periodic way. The interval of how long an answer is shown can be set for each individual activity of this type. A red buzzer button can be pushed to select and submit the currently shown answer. Although being so similar to Simple Questions, the different visualization and the fact that not only knowing the right answer, but also hitting the buzzer button at the right moment (the interval may be chosen quite small), enhance the game experience. An example is shown in Fig. 5. There exists also a multiple-choice version of this activity type, where more than one answer can be selected or unselected by the buzzer button, and the selected answers can be submitted through a dedicated button or are automatically submitted when time is up.
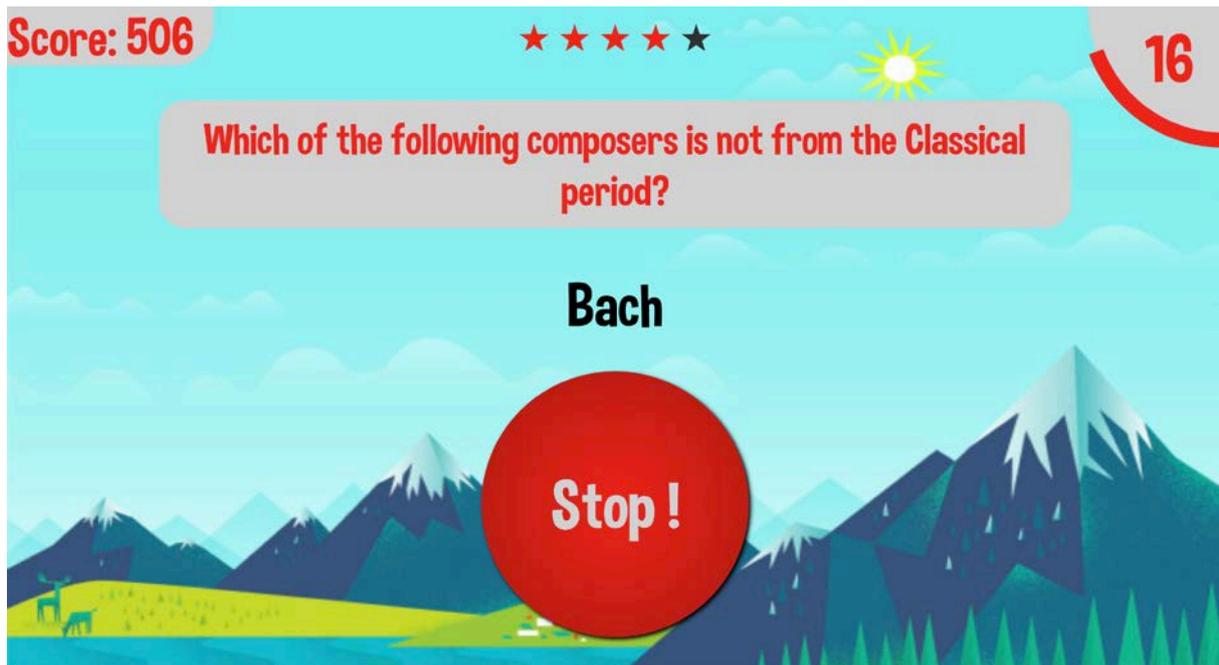
Fig. 5: Simple Focus

Point-and-click is an activity type that allows the user to put a pin on an image. The teacher can define a solution area in which pins are considered correct. The usage domains for this type of activity are manifold, it could be used in geography classes to pinpoint a city on a map to see which player put her pin the closest, or, as shown in Fig. 6, in biology classes to annotate an anatomical diagram.

Building Pairs is an activity type where players need to connect concepts from a left column to concepts in a right column, whose order can be randomized. This is similar to the "Match" game in Quizlet, but can be used for other purposes than vocabulary learning as well, as shown in Fig. 7. Clicking on a pair of concepts will be represented by a line. When the solution is shown, lines on the student screen will be colored green or red, depending on the correctness.

Catch'em all is similar to Quizlet's *Gravity* game. In this activity type, right and wrong answers are falling like apples from a tree and can be caught by a game figure which can be moved using the arrow keys or touching the screen. Apples with right answers should be caught, whereas apples with wrong answers should not. Although similar to a regular multiple-choice question, this is, apart from multiple-choice version of the Focus activity, the third visualization of the same underlying question type, but the variety of visualization should keep the students enthusiastic about the game play. An example from the computer science domain is shown in Fig. 8, where apples representing compiled programming languages should be caught but apples representing script languages should not. An apple representing the "Java"

programming language is correctly caught, whereas the approaching "PHP" apple should better be avoided.
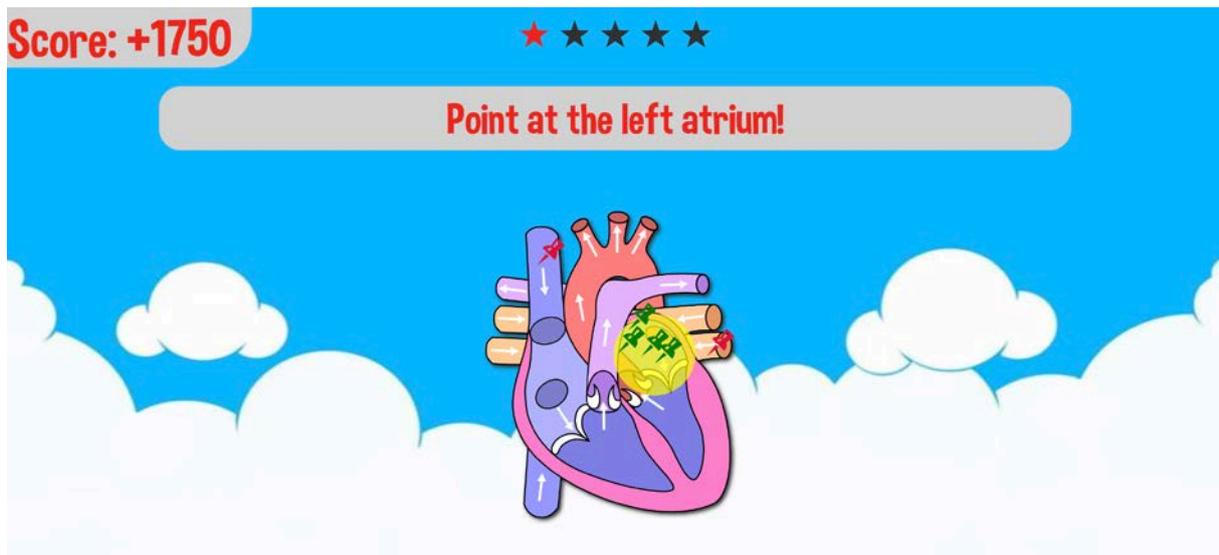

Fig. 6: Point-and-click – The solution area is represented by the yellow circle

Fig. 7: Building Pairs

A last activity type we have designed is *Ordering*, which is similar to the *Jumble* game in Kahoot! A set of answers needs to be dragged into the correct order. As a general difference to Kahoot! and like in Quizizz or Socrative, answers can be seen on the student device. The choice of Kahoot! not showing a textual representation but only the colored buttons might lead to confusions in this particular activity type. We show an example in Fig. 9, this time from the iOS app.

This is only a limited set of activities we have designed and implemented, partially based on existing solutions. However, it shall be emphasized again that the architecture of our framework allows a seamless integration of additional activity modules for an even more diversified game experience.

The variety of activity types may actually avoid a wear-out effect of using GSRS frequently. In a study by Wang, using Kahoot! over 5 months had only a little wear-out effect with respect to student engagement and motivation [4]. Over 90% of the students stated a desire to play Kahoot! quizzes at least once a week. The author claims that the wear-out effect might

increase if a GSRS is used frequently in many courses, but that this might be leveraged again by *"providing many different games and game modes to keep the gameplay fresh and provide variation for the students"*.
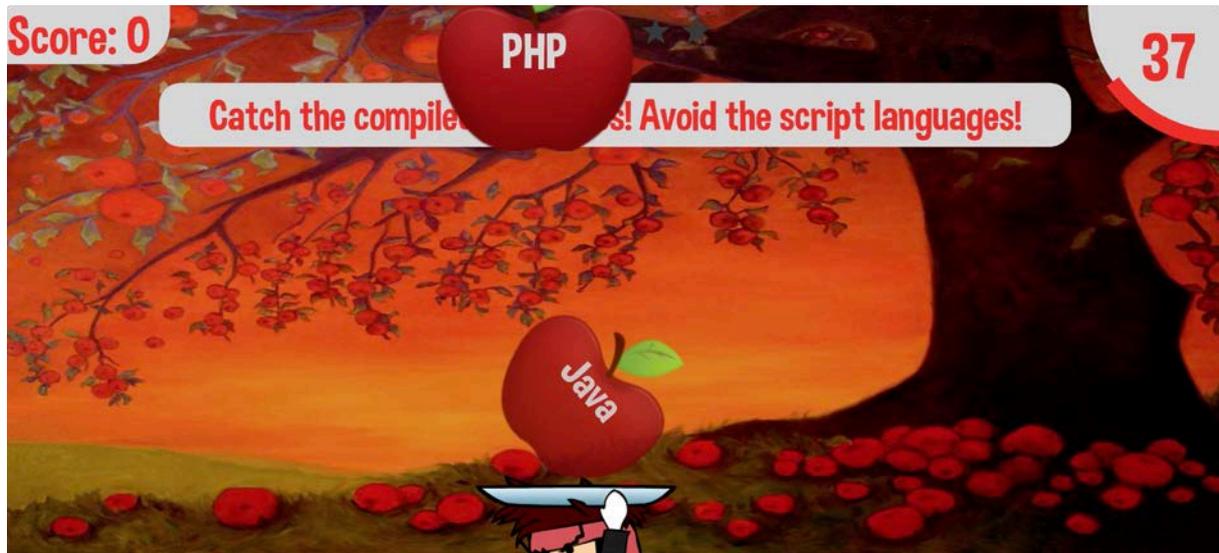
Fig. 8: Catch'em all
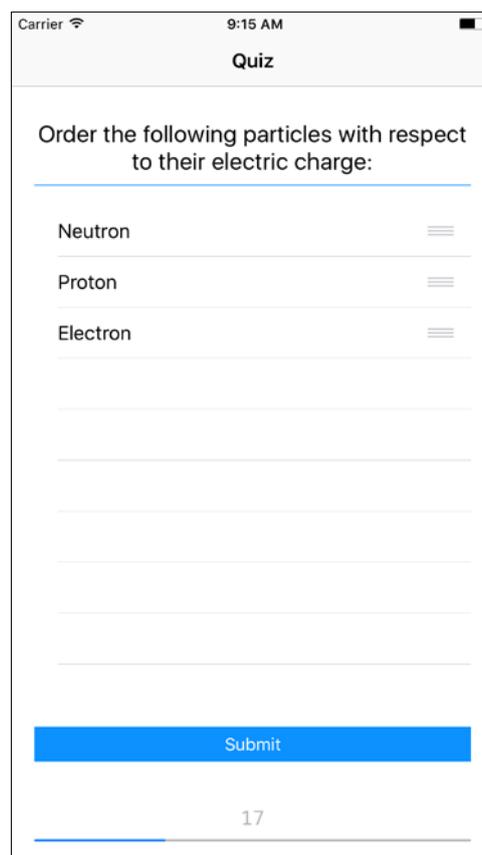
Fig. 9: Ordering activity in the iOS app of Yactul

3.4 Authoring Activities

As mentioned before, the ecosystem of Yactul is composed of a classroom tool, which teachers can use as a GSRS during lecture slots to play quizzes with their students, and a mobile app, focusing on the individual student's progress.

Of course, in order to be able to play quizzes, teachers will first have to author activities. They can do so by accessing the Yactul administration page and create or modify activities. As every activity type might require a different authoring process, authoring of activities is delegated to activity-specific authoring pages defined in the respective module.

In Yactul, quizzes are heterogeneous lists of activities, meaning that different activity types can be mixed, in opposition to Kahoot! In addition, activities can be reused in different quizzes, like in Quizizz. Different quizzes can be organized into quiz groups. This is particularly useful if a teacher has different courses and wants to have all her quizzes organized with respect to these courses. This is not possible in Kahoot! Quizizz provides so-called *Collections*, which are tags that can be assigned to quizzes, so that the teacher can afterwards filter for these tags. In Yactul, single activities can also be tagged. These tags can help the teachers to filter through activities when building a quiz. Apart from this, if tags are used to annotate activities with learning concepts an activity is focused on, students can later on filter activities and create on the fly targeted quizzes on certain topics, as described in section 3.6.

3.5 Classroom Quizzes

3.5.1 Quiz Initialization

When a teacher wants to play a quiz in Yactul with her students, she can create a quiz room which can be accessed by a PIN that is shown on the projector screen. This PIN metaphor is also used in Kahoot! and Quizizz. Students can then enter the PIN and their nickname and wait until the teacher launches the first activity. During the game, students can see both questions and answers on their screen, together with their current score and the remaining time. They do not have to look up at the projector screen and map colored buttons representing the textual answers shown on the projector screen. In general, the approach chosen by Kahoot! would probably not be a viable solution for some activity types in Yactul like *Point-and-click*.

3.5.2 Results, Evaluation & Statistics

At submission, either explicitly or when no more time is left, each device transmits the chosen answer(s) to the core module of the Yactul installation. Latter delegates the answers to the module responsible for the activity. This is necessary, as the evaluation of an activity is completely agnostic to the core module. The whole business logic with respect to evaluation and score calculation is done at the level of the activity-specific module, as the core module does not hold any information on the correct answer, and each activity may choose a different way of attributing a score specific to the activity type. In general, the score is calculated based on the difficulty of the activity (which can be set by the teacher during the authoring process), the time needed to answer it as well as activity-specific factors. For instance, it could be desirable to punish guessing the right answer of a multiple-choice question: By selecting all answers and not being sanctioned for wrong answers, a student could take advantage over others that are playing fair. Other activities might calculate a score based on a non-boolean decision, e.g. the accuracy of pinpointing in a *Point-and-click* activity.

The evaluations and scores are then sent back to the core module. At this point, user statistics are stored, e.g. how many users got the question wrong, how long they needed to answer etc. This information is not stored at the level of activity modules, as they can be used for different Yactul installations. The information is stored in an anonymous way to ensure the privacy of students. Teachers can later analyse the data to understand which topics have been less well understood. Statistics on how many students chose which answer are shown on the projector screen (as seen in Fig. 4). An individualized feedback is sent to the students' devices to show the selected answer(s) and the correct one(s). Each solution-screen is also activity-specific. For instance, the *Point-and-click* activity shows a solution area and pins, whereas *Building pairs* shows the correct links. The feedback is visually enhanced through a coherent use of

colors and icons to distinguish correct and wrong answers, as well as answers that were not selected but should have been.

At the end of the quiz, or, if the teacher chooses so, between activities, a leaderboard of the 5 best-performing players can be shown, as seen in Fig. 10. Doing this during the quiz can motivate students to increase their performance. Gamification in Yactul is realized by collecting points during the quiz, trying to climb up the leaderboard and playing against time, but also activity-specific game elements like quick reaction in *Focus* activities, moving quickly in *Catch'em all* activities or accuracy in *Point-and-click* activities contribute to the game experience.

3.5.3 Dynamic Adaptation of a Running Quiz

In contrast to existing solutions, Yactul allows the teacher to modify a running game in different ways. As shown in Fig. 11, the teacher is provided with a timeline, similar to those in movie editing software. During the quiz, she can add or remove activities from the quiz, rearrange the order of upcoming activities, or change the timing of an activity. Even a currently running activity can be awarded more time, if the teacher sees that students are struggling with a question. This can be achieved by simply enlarging the activity on the timeline. A vertical line shows the progress of the quiz and of a currently running activity, as known from media players.

Fig. 10: Leaderboard

Each activity shows an icon representing its type as well as the time currently assigned to it. The magnifying glass allows the teacher to open and edit the content of an activity even during the running game. This is useful to quickly adapt and streamline a question on the fly, integrating discussions and feedback from the current lecture. Finally, the teacher has the possibility to show the leaderboard between activities and go on with the next activity. Questions are not played in an auto-forward mode, allowing the teacher to discuss the solution of an activity with her students. This whole view is only intended for the teacher's screen, whereas the projector screen will not show any of this information rather than the currently running activity, the solution or the leaderboard.

3.5.4 Responsive Design

As mentioned before, the activity views shown on the screen of the students' devices in the classroom tool are following the responsive design principle, which is important to allow a seamless user experience in a BYOD setting. Depending on the screen size, the arrangement of activity elements will be changed, as can be seen in Fig. 12. Here, the same question is

shown on an iPad and an iPhone, but the elements of the view (descriptive image, answers) are rearranged according to the screen dimensions.
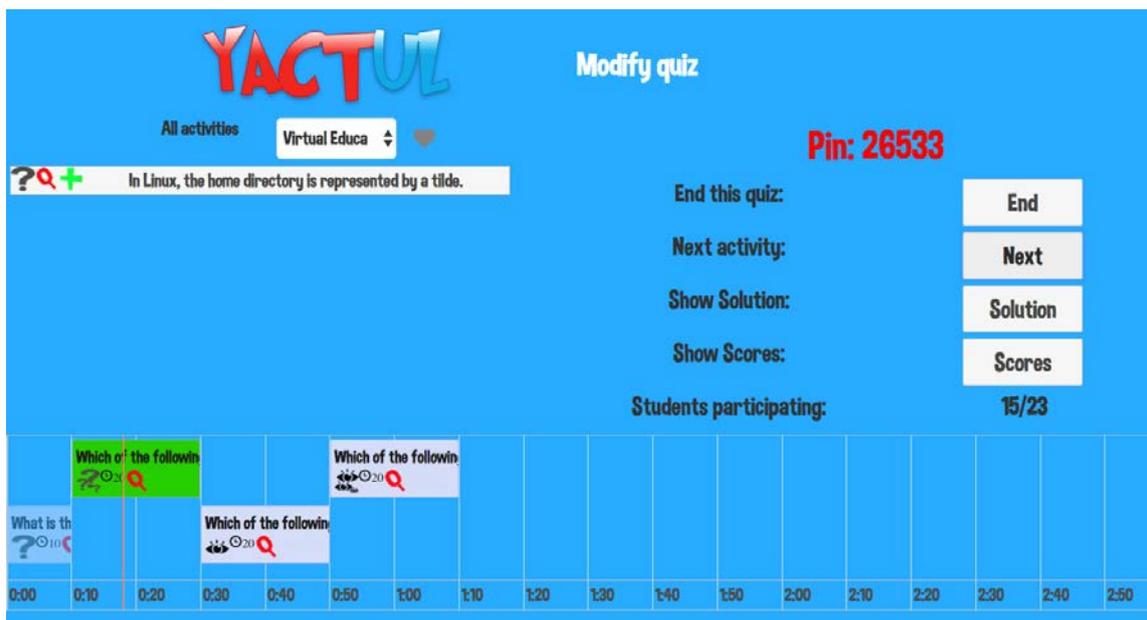
Fig. 11: Teacher screen during a running quiz with the timeline of activities at the bottom
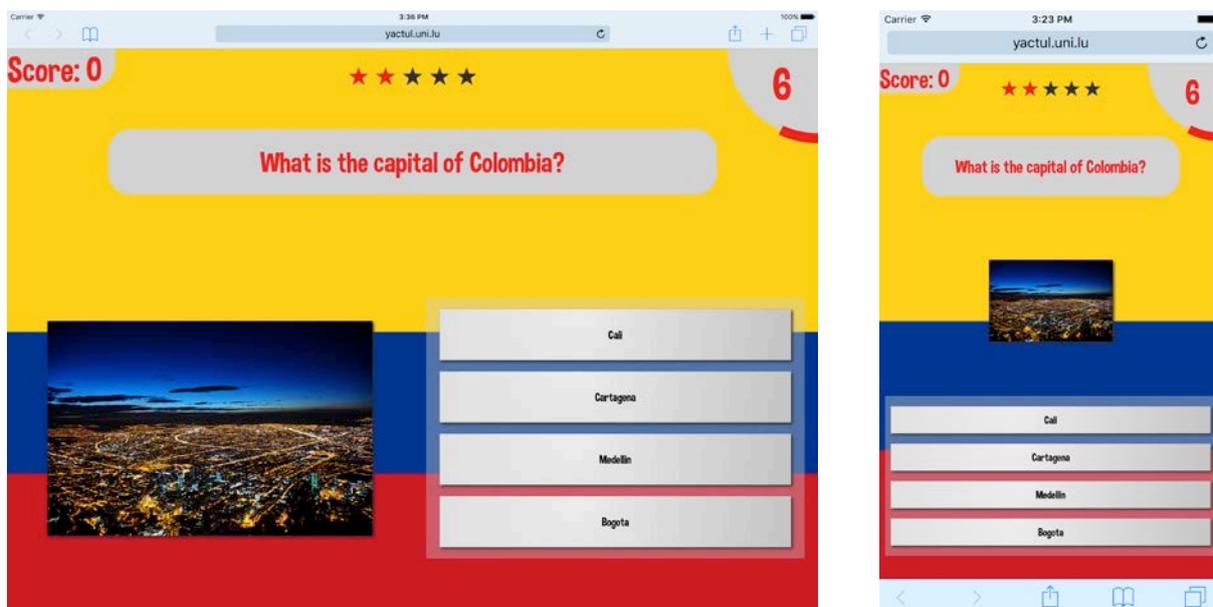
Fig. 12: Responsive Design - Comparison between student screens on an iPad and an iPhone

3.6   Offline Learning

Apart from the classroom tool, which represents the GSRS component of our ecosystem, we extended the user experience outside the lecture to provide a continuous learning experience by fostering the learning process of the individual student. Students can review the proposed activities and continuously improve their performance and thereby learn the underlying aspects. The apps are designed in a way that connection to the Internet is only needed when downloading the quizzes from a Yactul installation, such that students can play even when they are offline (e.g. traveling abroad without a data plan). The quizzes and usage statistics as well as the business logic are all stored on the device. Vocabulary learning apps like Memrise still need a stable connection to the Internet, at least in the non-Pro version.

The app, that exists for both iOS and Android, provides two modes. The first mode allows the user to replay the quizzes from the class in the exact constellation as during the lecture, i.e. organized in quiz groups (which can represent subjects) and quizzes (which can represent the different weeks in the semester). The student can select one or more quiz groups and quizzes and replay them in the same order as in the class. This is intended to help *sequential* learners [10].

The second mode is called Coaching. In this mode, the student can select, from the available quiz groups, a set of topics she wants to emphasize her training on. These topics can be used in activities across different subjects, so reviewing activities on a certain topic can help *global* learners [10]. Playing quizzes in both modes keeps track of the individual student's learning progress by storing usage statistics (e.g. how many times has an activity been answered wrong). This is important for the Coaching mode for two reasons. First, the list of topics is presented with colors. Topics that have been answered overall correctly in the past will tend to a green color, whereas topics that have been answered wrong and thus need a particular attention will tend to a red color. This color gradient, as shown in Fig. 13, gives a visual cue to the student in order to help her focus on particular topics that she has not understood well so far.

Second, the Coaching mode being focused on formative assessment, the quizzes generated from the select topics follow the Leitner system [11], a model widely used in flashcard software for spaced repetition and based on the work of the German psychologist Hermann Ebbinghaus, who formalized the concept of the forgetting curve. The Leitner system allots numbered decks (boxes), where cards (in our case activities) move to a higher-numbered deck when the answer was correct or move to a lower-numbered deck (or directly the first one) when the answer was wrong. Cards in higher-numbered decks are less frequently asked, as they are less prone to be answered wrong, due to their advancement to a higher deck. In the mobile apps of Yactul, whenever an activity is played, the outcome decides whether an activity is rather probable to be asked again in a subsequent coaching session or not.

Fig. 13: Visual cue represented by a color gradient to indicate which topics need particular attention in the learning process

In addition, when an activity is answered wrong, the quiz gets dynamically adapted to the needs of the student. In order to check whether it was only a punctual misunderstanding of a specific activity (e.g. due to the phrasing of the question), activities on the same or related topics are proposed, at the same difficulty level as the previous one. If these subsequent activities are still answered wrong, this may be a hint that the very topic has not been grasped well by the student. However, to be sure that the issue does not come from the difficulty level, activities on the same topic but with a lower difficulty level are proposed next. In the end, the student will benefit in upcoming coaching sessions from the visual cue of colored topics based on previous outcome and on the higher probability of being asked activities again that caused problems in the past. Actively knowing which topics are not well understood will help the student concentrate on these topics when she consults her learning material.

Note that gamification is still provided in the mobile apps, even though there is no direct competition with other players anymore. At the end of each quiz, a score indication is shown. The variety of activity types as well as the time pressure still ensure a pleasant game experience, while focusing on the individual learner's progress. Both versions of the app have been designed to allow a seamless user experience between both platforms, as can be seen in Fig. 14.
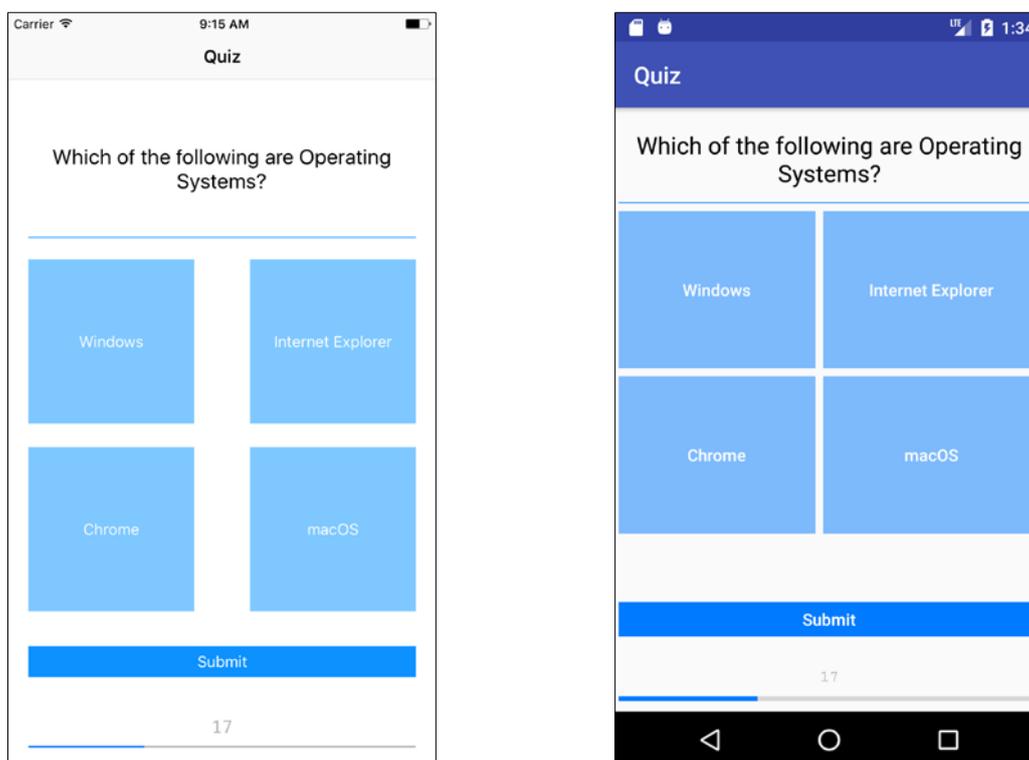

Fig. 14: Consistent design on iOS and Android to ensure a seamless user experience on both platforms

4   Conclusions & Future Work

In this paper, we have presented Yactul, an extensible game-based student response framework for active learning. Our architecture is extensible with respect to new activity types, which is an enhancement to state-of-the-art solutions. Through a set of activity types, we have illustrated its usability across different study domains. New activity-types can be easily added to provide a wide variety of games. In opposition to existing solutions, the teacher has a lot of flexibility to adapt a running quiz. Furthermore, our ecosystem comprises a mobile app that goes beyond the limits of the classroom. While collaborative learning and discussion of learning aspects within a gamified environment is the focus of the classroom tool, the app is

centered on the progress of the individual student when studying in private. It allows her to study on her own the proposed activities from class while keeping track of her progress, providing formative assessment and recommending topics that need to be studied with particular attention. The offline availability enables her to study anywhere and anytime. The combination of the collaborative experience in the classroom and the individual assessment using the mobile app provide a continuous learning experience within our ecosystem.

We have several ideas for future work. First, we are still in early stages of using Yactul in the classroom. Evaluating its usability may improve the current prototype with respect to the needs of different study domains. We want to introduce a group mode in order to foster collaborative learning. Members in a group may collaborate to answer a same activity together across different devices. For instance, this could be useful for a collaborative version of a phrasal template word game like *Mad Libs*. Additionally, members could work on different tasks, and the outcome of one could influence others. The game experience would be expanded to give correct answers to not negatively impact other players in the same group. For the mobile app, we are currently working on integrating learning material corresponding to the learning aspects in activities and thereby provide ad-hoc support. Also, context-aware recommendations of activities, e.g. before an exam, might be conceivable.

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