

Science Quizzing

The Heimann twins, Alex and Mark, are usually extremely entrepreneurial but this year they are turning their attention in a more philanthropic direction. They are creating a non-profit organization called ScienceQuiz to promote science by encouraging students to participate in a series of science quiz events. Students will register via organizations (typically schools) and form teams to compete by answering science-related questions and scoring points for their teams. Alex and Mark know that they need a web-based application to help them track the different science quiz events and the standing of students and teams – to that end, they have recruited you to build this application to the specifications listed below.

Science quizzing foundations

The purpose of science quizzing is to motivate students to learn more about science by having them engage in friendly competitions where they can demonstrate their knowledge by answering science-related questions. ScienceQuiz (the organization Alex and Mark are setting up to run these events) works by recruiting local organizations in the community – typically schools but can also be a variety of non-profit organizations – to enroll students and form teams to compete in events. These quizzing events occur at the host organization’s location and they occur at various times across an academic year.¹ A host organization may or may not have any teams in the particular event they are hosting and not every organization is required to host an event. Some organizations are large and have many teams and students participating, but others have few teams and students. Some organizations in the system have no teams at all and simply volunteer their facilities as a community service and serve as event hosts.

The focus at every event is on the quizzes themselves and every quiz is identified by its room and round. During an event there are usually multiple rooms holding quizzes during the same round. Each round and room of quizzing is held in a space with three teams, a quizmaster, and a scorekeeper. The quizmaster’s job is to oversee the quiz, ask the questions, identify the person answering each question, and resolve any disputes. The scorekeeper tracks the scores for all three teams as well as the individuals on the teams and identifies which quizzers may have “quizzed out” or “erred out” (more on those terms shortly). At an event, there can be multiple rooms holding quizzes in any given round; indeed, at larger events it is not unusual for there to be 10 rooms all holding quizzes during any particular round.²

At the end of each quiz round, the scoresheet is turned in by the scorekeeper to the stats room, where the results of that quiz for both teams and individuals are certified by a ScienceQuiz administrator and then entered into the system you are building. A copy of the scoresheet used is a part of the materials

¹ An academic year runs from August 1 of a calendar year until July 31 of the following calendar year.

² The number of rooms that can hold rounds at an event depends in large part on the size of the physical location hosting the event; large buildings typically have more rooms that are able to hold a quiz round. The number of rounds at an event can vary, but are always a multiple of three (because there are three teams to a quiz).

provided and it would be useful to review that.³ After all the rounds at a particular event are finished, total team and individual scores are tabulated and prizes are awarded to the top five teams and the top five individuals for that event in each division. The system you are designing will be particularly helpful in this process, calculating final results for an event quickly and accurately.

Alex and Mark want to promote science learning for students of all ages, not just high school students. Of course, it is blatantly unfair to ask third graders to compete against high school seniors in terms of science knowledge. To that end, they have created two divisions for students and teams to compete in. The first is the “senior” division for students in grades 7-12 and the other is the “junior” division for students in grades 3-6. Students and teams only compete with others in their division. At some point, Alex and Mark would like to subdivide this further into “elementary”, “middle school”, and “high school” divisions, but for now there are two problems. The first is that creating more divisions brings additional structural complexities that they are not prepared to deal with until the overall size of the ScienceQuiz program grows significantly. The second is that the definition of the latter terms varies from area to area. In some cases, middle school starts in sixth grade and in seventh grade for others; likewise, high school starts in most places in ninth grade, but in some places starts in tenth grade. Given these differences (and the fact that schools make up the overwhelming number of participating organizations), the Heimann twins are simply going to stick with two divisions – junior and senior – for the foreseeable future and we will consider those options fixed.

All teams can have up to five students assigned to the team, however, at any one time there can be no more than four quizzers on the platform, participating for the team. Teams can substitute quizzers if a student “quizzes out” (gets four correct answers in a quiz) or “errs out” (makes three errors in a quiz), or the team coach calls a time-out and informs the scorekeepers that he/she is making a substitution. Active teams must have at least one person on the team. Organization leaders cannot change the team rosters during an event (for integrity sake, team rosters are locked the morning of an event and cannot be edited until the end of the day), but leaders can change the team rosters between events between the months of September and December. On January 1, team rosters are fixed and only the overall ScienceQuiz administrators (for now, Alex and Mark) are allowed to make team roster changes until the Finals conclude in June.

Science quizzing mechanics

A particular quiz round consists of 20 questions. Each quizzer sits on a bench of pressure-pad seats that detects when he/she jumps and sends that information to a control panel overseen by the quizmaster. When the first student jumps, his/her light on the control panel goes off and the quizmaster recognizes the student by his/her team and position number (students are ranked 1-5 on the team, with 1 – the team’s best quizzer – serving as the team captain). Once recognized, the quizzer

³ One question might be why not skip the paper scoresheets altogether and directly enter scores into the system. Experience with other types of quizzing have shown that it is valuable to have a paper copy for auditing purposes and other quizzing leagues keep the paper copies of all scoresheets in a central location and do not recycle these papers until the end of the academic year. ScienceQuiz is learning from those experiences and will adopt similar policies.

has 30 seconds to correctly answer the question. Below is a picture of a quizzer (white team, #3) answering a question for the quizmaster while his fellow quizzers look on:



If a quizzer's answer is correct, the quizzer and the team each get 20 points. If the quizzer cannot answer the question in the 30 seconds allotted or answers incorrectly, then the quizzer commits an error. At most, a student can answer four questions correctly; after that, they are considered "quizzed out".⁴ If a student quizzes out without committing any errors, both the quizzer and the team get a 10-point bonus. If three people on a team get a question correct, then the team gets an additional 10-point bonus, referred to as the "third person bonus". If the team has four people get at least one question correct (which does not happen often), then they get a fourth person bonus of 10 points; the same is true for the extremely rare cases of a fifth person bonus after five students on a team correctly answer a question.

The first error for a quizzer does not affect his/her individual score, but for the second and third errors, both the quizzer and the team are penalized 10 points. During questions 1-16, teams are not penalized 10 points until the third team error, unless the first two errors were made by the same person.⁵ Starting at question 17, error points are in effect and any team error immediately is penalized by 10

⁴ Part of the reason for quizzing out after 4 correct questions is that it prevents a "Sheldon Cooper" type quizzer from monopolizing the quiz and not giving his/her teammates an opportunity to answer questions. Given that questions are in different categories and team members may choose to specialize in a couple of areas, it also adds a strategic element to the event to be considered.

⁵ For example, if quizzer 1 commits an error, there is no penalty at all for this first mistake. If the same quizzer errs on the very next question, both the quizzer and the team lose 10 points. However, if instead quizzer 2 errs on the very next question, then neither quizzer nor team are penalized. However, if after quizzers 1 and 2 err, if quizzer 3 on that team errs, even though it is his/her first error, then the team gets a 10-point penalty; however, quizzer 3 still gets grace and does not suffer an individual penalty.

Another way to look at the team penalties is that a team is not penalized until the third team error unless either (A) the first two errors are both made by the same person, or (B) error points are in effect, starting at question 17 (see note below). Students are never penalized on their individual score for their first error.

points (but the individual quizzers are not penalized).⁶ The quizmaster may, at his/her discretion, assess other 10-point penalties for inappropriate behavior, such as purposely distracting other quizzers, although such penalties are quite rare in practice.

In terms of individual scores, it is important to track both the scores for each round as well as the number of questions correct and the number attempted each round; this is because the tiebreaker used when two quizzers have the same total score is their accuracy rate, with the higher prize going to the person with the greater accuracy.

In terms of team scores, the raw score for each team is converted into something referred to as “team points” based on the following rules. The first-place team gets 10 points for winning the round, plus a bonus of 1 point for every 10 raw points over 100 that they have scored. The second-place team gets 5 points for coming in second, plus a bonus of 1 point for every 10 points scored over 60. The third-place team gets 1 point (unless they fail to show up for the round, in which case they get a zero) regardless of their team score (even if it’s negative, they get 1 team point), and they too get a 1-point bonus for every 10 points scored over 30. If two teams tie for a particular place, both teams are awarded the points at that level. Team points are used for awarding prizes at the end of an event, but raw scores can still matter. In the event of a team tie, the first tiebreak is head-to-head matchups (if the teams met directly in a quiz, whoever won that particular quiz wins the tie-break); if that is tied, then the second tiebreak is raw points and the team with the most raw points wins the tie-break.⁷

As a miscellaneous note, teams quiz against each other in groups of three and each team sits on a set of pressure-pad benches that are arranged in a semicircle around the quizmaster’s table. (You can see that from the photo provided earlier.) For the most part it doesn’t matter to teams which set of benches they have to sit on during a round; however, for some strong senior division teams, there is a preference for the middle benches (position 2) because it allows for better lip-reading of the quizmaster and slightly quicker jumping. Because it is important to some quizzers, it is necessary to distribute as evenly as possible the number of times a team is in a given position in a room. Additionally, a team must all sit together on the same set of benches, but they don’t have to sit in rank order – they can sit in any order that they choose.

Access, security, and auditing

In terms of users, of first importance are the overall system administrators from the ScienceQuiz organization who have unlimited power to read and make changes to the system at any time. All quiz matchups and all results are entered by a ScienceQuiz administrator. For other organizations, there are two levels of people. The first is the organization leader and the second is the coach. Organizational leaders cannot create their organization (only ScienceQuiz officials can create new

⁶ The idea of “error points in effect” is that in an extremely close quiz, in the closing moments a team that hasn’t erred yet can’t purposely jump on a question they know they don’t know simply to prevent the other team from answering and overtaking them for the lead, without suffering some team consequence in the process. There are no “fouls to give” in science quizzing.

⁷ In the extremely rare event that the team tie cannot be resolved by either tiebreaker, then the teams will share the title and the higher trophy will be determined by coin flip. The same goes for ties at the individual level.

organizations), but they have the freedom to edit organizational details once the organization is approved and created by ScienceQuiz administrators. The organization leader can also enroll students and coaches into their organization and put them on teams and edit the team rosters anytime between September 1 and December 31 of a given academic year. Organizations typically have one leader, but it is possible to have two leaders. Finally, organization leaders can also serve as team coaches and be assigned to teams.

Teams are assigned one coach from that organization. Smaller organizations may have only one coach/leader who oversees all the teams, but there must be a coach responsible for every team. Coaches who are not organizational leaders have read access to all students and teams in their organization. However, they cannot change team rosters – only the organization leader or the ScienceQuiz administrators can do that. Still, there are times at the last minute when a student gets sick or otherwise has to miss an event. In those cases, the coach can go in and mark those students as inactive for the day and they will not appear in scoring options and not have any results recorded.

Students cannot log into the system and have only limited read-only access to the system. Because ScienceQuiz works with minor children, it is important that no sensitive student records be kept on the ScienceQuiz system. Any contact information, such as home addresses, phone numbers, email addresses, should be handled by the local organization that the student is enrolled with and not stored on ScienceQuiz servers. While a student's date of birth information is prohibited on ScienceQuiz servers, it is necessary and permissible to store a student's current grade in the system.

As for destroying records, Alex and Mark want to maintain good historical records for auditing purposes, so rather than delete a record, they would prefer to mark organizations, leaders/coaches, students, and teams as inactive. Inactive records would not appear in dropdown lists for making new team assignments or creating matchups, but still be accessible in the database if an audit were needed.

The application needs to be built with Ruby on Rails, version 5.2.4.4, using Ruby version 2.6.6. Alex and Mark have heard from their dad repeatedly the importance of unit testing and all models must have 100 percent unit test coverage. There will be other tests, such as integration tests using cucumber, that will be provided later in the semester and it is expected that the application should be able to pass all tests prior to being deployed on the ScienceQuiz servers.

Additional requirements will be given in the second half of the semester.