
Jeffrey D. Ullman
Stanford University and Gradiance Corp.

Abstract
Gradiance On-Line Accelerated Learning (GOAL) is a system for creating and automatically grading homeworks, programming laboratories, and tests. Through the concept of “root questions,” Gradiance encourages students to solve complete problems, even though the homework appears to be in a multiple-choice format. The instructor has the option to offer a hint or advice every time the student gets a wrong answer, and the student may be allowed to try each question until getting it right. This manual covers how one uses the Gradiance system to create root problems, how one assembles questions into homeworks, and how one issues assignments to a class.

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1 Root Questions

A root question is a multiple-choice question that has several right answers and many wrong answers. In this section, we first explain the motivation for using root questions and then go through the process of creating root questions using the Gradiance system.

1.1 Motivation

Root questions automate the process of assigning and grading “analytic” questions. In conventional Math, Science, or Engineering homework, a student is asked to solve a problem and hand in the solution to a TA, who grades it and hands it back a week or so later. With root questions, the student is asked to solve the same problem, but their knowledge of the answer is sampled by a multiple-choice question. If they get the question wrong, they are given a hint, called a choice explanation, and invited to try again. As a result, homework is no longer a little test, but rather an opportunity for students to learn how to solve problems in the subject matter of the course.

While the instructor has options, we believe that the most effective use of root questions is in groups of 4–6 questions, called a homework. Students should be allowed to take the homework until they get all the questions right. By grouping several questions together, and expecting the student to work out all the questions, it is unlikely that one could get a perfect score by guessing. Yet as they solve the individual problems, and keep the answers in front of them for reference, it doesn’t take long for students to pick right answers if they have to repeat a homework to get a perfect score.

Instructors and TA’s are spared the effort of grading many nearly identical homeworks, while students appreciate the immediate feedback in the case of errors. In addition, because we randomize both the order of questions and the selection of right and wrong choices, there is some inhibition to cheating, as students cannot easily pass information like “the answer to question 3 is b”; there is no notion of “question 3” or a particular “choice b.”

To see how root questions work, let us consider a typical long-answer question from database systems:

If relation $R$ has set of tuples $<\text{some set of tuples}>$ and relation $S$ has set of tuples $<\text{some other set of tuples}>$, what is the natural join of $R$ and $S$?

A root question about joins of relations would be phrased as follows. The stem (portion before the choices) of the question would give particular, small sets of tuples that constitute the relations $R$ and $S$ and then say: “compute the natural join of $R$ and $S$, and indicate which of the tuples below is in the natural join.” The student sees several choices (typically four choices), one of which is a randomly chosen tuple of the answer, while the other choices are chosen from a list of incorrect answers provided by the question designer. As a result, the student has to compute the join, just as in the conventional form of question, but they get their answer sampled for correctness, rather than graded in its entirety. If they make a wrong choice, they get a hint, such as an explanation of why their choice is wrong.

The question designer gives a list of possible correct answers. For this question, the list would naturally consist of all the tuples in the natural join of these relations. The designer also gives a supply of incorrect answers, which in this case could be any other tuples. To make the distractors (incorrect answers) look plausible, it would be wise to give them the right number of components and to use values that appear in $R$ and/or $S$. 

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Finally, the designer should provide choice explanations, at least for the incorrect answers; these are normally shown to the student if they make the corresponding incorrect choice. In general, a choice explanation could be a reason why the choice is incorrect, or perhaps an outline of how to approach the problem. For instance, in the case of the question about joins, we could explain to the student which tuples would have to be in $R$ and/or $S$ for the incorrect choice to be correct. That explanation not only should convince the student that their answer is wrong, but give them the reasoning needed to figure out how to work the problem if they are unsure of how to compute joins. In “premium editions” of the questions, associated with a particular textbook, the choice explanation might also include a reference into the text for relevant passages.

1.2 Designing Root Questions

We'll go through the mechanics of entering root questions into the Gradiance system momentarily, but to start, you need to think of an idea for the question. While there is no sure way to invent a good root question, start by thinking of an ordinary, long-answer question, just as you would for an ordinary homework assignment. Visualize the answer. Unless the answer is something like “6,” it probably has distinct components, just as the answer to the example question about joins, above, did. Phrase your question so that it asks not for the whole answer, but for an identification of a part of the answer. The correct choices may turn out to be pairs, where the first component of the pair is a description of which part of the answer is requested, and the second component is a proposed value for that part.

As an example, you will find in our question bank a question about computing PageRank — the Google technique for estimating the importance of Web pages. The stem shows a simple example of a graph representing links among three Web pages, and the student is asked to compute the PageRank of each of the pages. The correct choices are pairs consisting of one of the nodes, and the correct PageRank for that node; the incorrect choices are similar, but with the wrong PageRank value for a node.

1.3 Entering a Question into the Question Bank

After logging on to the Gradiance system as an instructor, go to the menu on the left and select Question Bank. You should see three options appear below:

1. **Find Questions:** Used to search for questions. We'll need this choice if we ever need to edit one of our questions, or just for browsing to see what other instructors have created.

2. **Create Question:** Used to enter new questions into the question bank.

3. **Upload File:** Needed to embed diagrams in our questions.

Click on **Create Question.** You should see a form to fill, with four fields:

1. **Question Type:** Normally leave this field at *Root Multiple-Choice Question.* The alternative is a conventional multiple-choice question with one correct answer, which is useful for tests, e.g., where you want students to take the question only once, and you want all students to get the same choices, for fairness.

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1The “outermost” details — logging into an instructor’s home page and going to the page to manage a particular class — are deferred to Section 5.1.
2. **Question Category**: Select the closest category.

3. **Difficulty Level**: The choices are 1–5, with 1 the easiest. You can leave this value at the default 3, but if your question is intended to be noticeably hard or easy, it would be a good idea to indicate that fact.

4. **Search Words**: These can be any list of words, separated by blanks. The purpose of these words is to make it easier to find questions on a topic later. They are especially useful if your question does not fit the predefined categories for your subject.

Having completed the form, click *Create Question*, and you will see another screen into which the question is typed. There are two large boxes, and smaller lines for entering correct and incorrect answer choices. The big boxes are:

1. The question text, i.e., the stem of the question, which the student sees.

2. A question explanation, which can, at the option of the instructor, be shown to the student after they have answered the question, or after the deadline for their homework.

The language used in this form is HTML, so you can format the question as you like, e.g.,

Let $\langle I \rangle R \langle /I \rangle$ be the relation with tuples $(1,2), \ldots$

Below the question stem are four boxes for entering correct answers and twelve boxes for incorrect answers. Again HTML is used in these boxes. You need not fill in all the boxes, and if you want more choices, there will be a way to add more on the next screen. After entering choices, click *Create Question*.

The next screen shows what you entered on the previous screen, and has place for you to add choice explanations for any of the choices. There are also four options on the bottom:

1. **Add New Choices** in case you want to use more than four correct and/or twelve incorrect answers.

2. **Delete Choices** to eliminate some of the choices you already have entered.

3. **Edit Question** to change the stem or question explanation (not choice explanations).

4. **Delete Question**, with the obvious effect. But note that the deletion needs to be confirmed.

To include choice explanations, click *Add Explanation* next to the choice you wish to explain. We advise that a choice explanation be given for each incorrect answer. For example, you may wish to explain why a particular choice is wrong, or give some general hints about how to solve the problem. However, we would not use the entire question-explanation as the explanation for an individual answer; the latter is best shown only after the homework’s deadline has passed. If you want to say “congratulations” for a correct answer, that is fine, but we generally leave the choice explanations for correct answers blank. **Hint**: Since choice explanations are frequently similar, be sure to use copy-and-paste.
1.4 Using Diagrams in Questions

If you need a figure as part of your question, select Question Bank → Upload File from the menu on the left. You are given a screen in which you can name, or browse for, the file that holds the figure you need for your question; its operation should be obvious.

You may address the uploaded file \( f \) by the path \( \text{./pictures/f} \). For instance, a question using the uploaded file \text{diagram1.GIF} might start out:

\[
\text{Consider the following E/R diagram:}
\]

\[
\text{<P>}
\]

\[
\text{<IMG SRC = \'\text{./pictures/diagram1.GIF}\'}}\]

\[
\text{...}
\]

1.5 Editing Questions

You may discover later that you need to change a question. The wording may be poor, or it may even be that some answers were misclassified as correct or incorrect. If so, do the following:

1. From the left menu, select Question Bank → Find Questions.
2. Fill out the search form that is presented to you. As a default, you search for only your own questions, which are the only ones you can edit.
3. Click Find. You should be given a list of the questions that match your search.
4. Locate the question you want to edit. Click on Details at the right. The question, with all its answer choices, should appear.
5. Click on Edit at the bottom. Now, the original form on which the question was created should appear.
6. Make whatever changes you wish; your options are the same as for the screen you get when you created the question (see Section 1.3.
7. Click Submit Changes, and the edited question replaces its old version. Note that if this question is currently being used in a homework, then the new version appears in the homework, and every student who later opens the homework gets an instance of the new version.

2 Managing Homeworks

There are two different approaches to creating a homework for a class:

1. Locate an existing homework. You may use it intact, or you may modify it by adding or deleting questions. You may also adjust certain parameters (see Section 2.2).
2. Create a new homework from questions. You may use either questions you have created or others that appear in the question bank.

Creating a homework is different from assigning to your class. Whichever approach you follow, you will have to assign to the class, as described in Section 2.2.
2.1 Creating a New Homework

Go to *Homeworks* in the menu on the left, and click it to open two choices: finding and creating homeworks. Choose *Create Homework*, which opens up a screen in which you place the following information:

1. Give your homework a *Title*, for example, CS145 functional-dependency homework. The words in this title field may be used later to search for homeworks, so it is a good idea to make this title descriptive.

2. The *Difficulty Level* is in the range 1–5; set it to something other than the default 3 if you feel another level is warranted. The level can be used when searching for homeworks, incidentally.

3. Enter a *Description* for your homework.

When you click *Create Homework*, the homework is created, but for the moment has no questions. You need to go to *Find/Assign Homeworks* in the left menu, which gives you a screen from which you can locate the empty homework you just created. [Note: in future editions of the system this step will be elided, and you'll be able to add questions directly.] There are two kinds of search for homeworks; homeworks already assigned to your class, and homeworks that you have yet to assign (default). The first may be searched for if you need to change the conditions of an assignment, and the second can be used to edit existing, unassigned homeworks.

After clicking *Find/Assign Homeworks*, enter any search restrictions you wish, and click *Find Homeworks* on the search screen itself. That will give you a list of matching homeworks. Identify the homework whose questions you want to select, and click *Details*. You will see at the bottom, four choices of action, with obvious meanings. We want to choose *Add Questions*.

In response, you get a question-search form like the one discussed in Section 1.5. Fill out the form to focus on the kinds of questions you want. Be sure at least to select a category. Click *Search*, and you will get a page with all the matching questions. You may examine a question, including its answer choices, by clicking *Details* next to that question. Use the check boxes in the column *Select Questions* to pick zero or more questions to add to your homework. Click *Add Questions*.

You are taken back to the screen that lets you add more questions. Repeat the process of adding questions until you have a complete homework; e.g., you may wish to add questions from a different category next. At this screen, you also have the option of selecting certain previously added questions and deleting them from the homework. The questions remain in the question bank. You now have a new homework in the bank of assignments, and you are ready to assign it to a class, either now or later.

2.2 Assigning a Homework to Your Class

You can assign students any assignment (homework or lab), either a publicly available assignment that someone else has created or an assignment that you yourself have created. The steps are as follows:

1. In the menu at the left, choose *Homeworks* → *Find Homeworks*, and search for unassigned homeworks.

2. From the list of available homeworks, choose the one you want to assign, and click *Assign*. If you are not sure whether or not to assign a homework, you can click *Details* first, to see its questions.
3. You are given a screen with the essential decisions to be made about the assignment, as follows:

(a) Pick the group to which you will assign. Normally, there will be only one group for a class. However, you may need an extra group for dealing with people who get time extensions, e.g.

(b) Change the homework title if you like.

(c) Fill out the Open Date and Close Date. For a homework, you might choose a week between opening and closing, but for a one-hour exam, you might choose 70 minutes, with 5 minutes leeway on either side of the intended exam time. Note the format of date/times, which follows the pattern in the defaults on the form. The day precedes the month, which is always a 3-letter abbreviation, followed by the year and the time on a 24-hour clock. Also, unfortunately, all times are in Pacific Standard Time, which is eight hours behind Greenwich Mean Time. We hope to provide an option to adjust time zones shortly.

4. You may now click Assign Homework and accept the Gradience defaults for homework management. These involve giving students an unlimited number of chances to do the homework, but impose a 10-minute interval between openings of the same assignment (to avoid rapid-fire guessing). Students get to see choice explanations and right/wrong information whenever they submit their work, and after the assignment closes, they get to see the complete problem explanation. If you want to control these options, see below.

2.3 The Advanced Assignment Screen

Instead of clicking Assign Homework, choose Advanced settings for homework assignment. You are then given a screen with the following options in addition to the basic options described in item (3) above. All choices are initially set to their Gradience defaults.

1. Points per Question (default: 3) and Negative Points per Question (default: 1). These allow you to score homeworks as you wish. For example, you may not wish to deduct for wrong answers; if so set Negative Points to 0. Or, you may wish to award 10 points per correct answer, by setting Positive Points to 10.

2. Question Randomization Type: The choices are:

(a) No Randomization: Every student gets an identical homework. If root questions are used, the selection of right and wrong answers occurs once, and the order of the choices is fixed.

(b) Display Randomization: The homework is fixed, but different students get the set of questions in different orders, and the same choices will appear in different orders for different students.

(c) Choice Randomization: The questions appear in fixed order. However, the order of choices is random, and if the question is a root question, the choices themselves are selected at random.

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2And the selection of the choices is random, so there really is some randomization going on, even though the specification is “No Randomization.”
(d) Full Randomization: (default) We recommend this choice for taking advantage of root questions in homeworks. Here, each time a student accesses the homework, root questions are presented with one random correct answer and randomly chosen distractors. The questions and their choices of answer are presented in random order.

3. Randomization Seed: Pick an integer to start whatever randomization process you have chosen. The default, 1234, is usually fine.

4. Number of Attempts Allowed: Choose how many times a student may try the homework. The choices are Unlimited (default), 1, 2, and 5. We recommend Unlimited for homework and 1 for exams.

5. Time Between Attempts: One of the first things we noticed was that some students treated the system as a challenge to get the correct answers without understanding the questions. If you think about it, a statistical analysis will almost surely allow you to identify correct answers, if you see random presentations of the homework enough times. To discourage such behavior, we allow them to open a homework only once per 10 minutes. You have the option to block the reopening of a homework for any number of minutes that you choose.

6. Number of Choices per Question: We use 4 as the default, but you may pick any number of choices between 2 and 6. All but one choice will be incorrect.

7. None of the Above Choice for: You have the option to use “None of the Above” as a choice for some or all of the questions. If so, then this choice will be managed correctly. If you use $n$ choices for questions, “None of the Above” may appear as the correct choice along with $n-1$ incorrect choices or along with one correct and $n-2$ incorrect choices. It is always the last choice, however.

8. Student Feedback after Submission: There are six options, which control what the student sees when they submit a homework. Each option includes all the information from the options above it on this list.
   
   (a) No Feedback: Students are not even told their score.
   (b) Just the Score: Students are told their score, but not which questions were right and which were wrong.
   (c) Individual Question Grades: Students see which questions they got right and wrong, but not the correct answer for those they got wrong.
   (d) Choice Explanation (default): Students see the choice explanation associated with their answer, if there is one. Otherwise, they are just told whether their answer is correct.
   (e) Question Explanation: In addition, to choice explanations, students see the complete solution to the problem. It is important that they not see this solution if they are allowed to resubmit work. It may even be risky to reveal the solution to one student if others are allowed to submit work later.
   (f) Answer Key: Students see not only the choice and question explanations, but the correct answer.

9. Student Feedback after Due Date: You have the same six options as for After Submission. This selection determines what students will see after the due date and time for the homework. We recommend going all the way with Answer Key, which is the default.
10. *Include in Score Reports*: When you examine grades for this homework, you can arrange to see only the most recent, the average, or the maximum of scores obtained by a student.

After making your selections in all the above categories, click *Assign Homework*, and you are done.

### 2.4 Repairing Homeworks

Possibly, as a homework is being done by your class, a bug will be discovered. If the problem is that a question needs to be reworded or its answer choices changed, use the question-editing procedure of Section 1.5. Note that the change will appear in your homework immediately; you do not have to manage the homework in any way.

However, if the homework itself needs to be changed, say by adding or deleting entire questions, a different procedure, outlined below, must be followed.

1. In the menu at the left, select *Homeworks → Find/Assign Homeworks*.
2. Set the *Search Scope* to *Homeworks Already Assigned* and fill out any other search criteria you wish. Then click *Search*.
3. Next to the homework you wish to change, click either *Details* or *Update Assignment*.
   
   (a) If you choose *Details*, you get the same screen that was discussed in Section 2; this screen lets you edit the assignment in the usual way. Students will see the altered assignment whenever they open it henceforth. Students who have a downloaded copy of the homework (i.e., they opened the homework but have not yet submitted it) will still see the old version, however.

   (b) If you choose *Update Assignment*, then you get the advanced assignment screen, as discussed in Section 2.1.

### 3 Laboratories

Currently, there are labs based on SQL and XQuery. SQL labs give the student a database schema, against which some SQL queries must be written; XQuery labs do the analogous thing in that language. In a properly designed lab, when the student makes a mistake that is semantic (rather than a syntax error), they are given an example database and shown both what their query did, and what it should have done. In unusual cases, the sample database will fail to exhibit their error. But if the lab designer is careful, that situation will occur rarely, unless the student is trying purposely to fool the system. Rather, in the normal situation, the student gets valuable help from the Gradiance system when they make a semantic error.

We assign a lab to a class as we did homeworks in Section 2.2. Begin from the left menu with *Lab Projects → Find/Assign Lab Projects*. Fill out the search form as for a homework, and click *Find Lab Projects*. You are presented with the available labs, and you may click *Assign* for the one you want. As with homeworks, it is possible to click *Details* first to check out what it is you are assigning.

When you assign, you are given a screen with parameters, analogous to the basic screen for assigning homeworks. Labs do not require us to manage root questions, so the choices are simple, and there is no “advanced assignment screen.” The only things you need to concern yourself with are:
1. The group being assigned.
2. The title, if you wish the students to see another title.
3. The open and close dates for the assignment.
4. The number of points per question.
5. Whether the instructor gets to see the most recent, maximum, or average score.

Note that students always get to take a lab as many times as they wish.

4 Managing Your Class

There are several tasks you will want to perform occasionally, as you teach your class. In this section, we shall cover getting grade reports, forcing an adjustment in the score a student gets for an assignment, and sharing your instructor responsibilities with TA’s.

4.1 Grade Reports

Start at the left menu, Reports. You will see three choices, so you can choose whether you want a report for the entire course (all students, all assignments), just the report for one assignment (all students), or just the report for one student (all assignments). If you pick Class Score Report, you get a two-dimensional table with columns for assignments and rows for students. You can download this table as an Excel spreadsheet, by choosing Save as .csv File for Excel below the table.

If you choose Assignment Score Reports, then you get a screen that lets you choose the assignment, and you get a table of students, with the same option to save that table as an Excel file. Similarly, if you choose Student Score Reports, you are enabled to select one student from your class and get a list of their grades in all assignments.

4.2 Appointing a TA

From the left menu, pick Class Administration — Setup TA. Enter the Gradience ID of your TA (who must therefore have a Gradience account, even if they are not taking any classes that use Gradience or teaching any). Clicking Add TA will give them powers equivalent to your own in managing your class.

4.3 Adjusting Grades

Occasionally, you may want to override the Gradience stored grade for a student. You can make the grade be anything you wish by the following sequence of steps. From the left menu, do Class Administration — Adjust Student Score. On the screen that results, enter:

1. The student’s Gradience ID,
2. The number of the submission whose grade you want to change. This information can be found by the student on the submission itself.
3. The new score desired.

Click Update Score, and you are done.
5 Becoming a Gradiance Instructor or Author

If you would like to use the Gradiance service for any purpose, including as a teaching tool for your database class (or other classes whose materials we can provide) start by sending email to support@gradiance.com, introducing yourself and telling us what you would like to do. If you plan to use one of the “premium packages” associated with a textbook, we would like to know that as well. By return mail, we will give you access to the appropriate URL.

Alternatively, you can first create your account, which will only have student privileges, and then email support@gradiance.com to become an instructor. For the Fall of 2004, there are only two sites that you can use:

1. www.gradiance.com/PH for the premium site based on the Garcia/Ullman/Widom database books, and
2. www.gradiance.com/freeDB for the basic version of the service.

You should sign up at whichever of these sites makes sense for your class, and tell your students to sign up at the same site.

5.1 The Instructor Home Page

When an instructor logs in, they get a screen with a left menu that covers basic account-management functions, and a body that allows the instructor to access their class or classes. In the left menu you will see options:

1. Home Page: You can always get back to this screen by clicking this choice.
2. Update Password: An option handled in a standard way.
3. Update Account: we should have your first and last names, and a current email address.
   Please enter them here if they are not already entered.
4. Log Out: The effect should be obvious.

In the body of the page you will see a “class portfolio.” You should find listed there all classes you have created. Clicking on one of them will send you to the home page for that class, with all the features for managing questions, assignments, and students that are described in this manual.

You also will see at the bottom of the page a way to register for classes. Registering for a class is what students do; instructors need to create classes as described in the next section. All Gradiance users, including instructors, have the ability to register for classes, since it is possible that a person will be an instructor in one class and a student in another.

5.2 Creating a New Class

You also have the power to create a new class. Click Set up a new class. You get a screen that allows you to describe the class. The things we need are:

1. A Class Code, typically your university’s designation, e.g., CSI101.
2. A Class Name, typically the title of the course, e.g., “Introduction to Database Systems.”
3. *Open and Close Dates* for the class. Presumably you will use the current date to open the class. Please do not keep classes open much beyond the time they will be needed, perhaps a month after the grades for the class will be submitted to your registrar. Since we may need to delete records after the close date, you should preserve copies of any grade sheets you might need in cases of dispute regarding grades that could arise after your class closes. Incidentally, questions you create will still be available to you if you teach another class later.

Click *Set Up Class Site,* and the new class will be entered into our system. The response screen includes a *Signup Token.* This token is very important; it is what students in your class need to give when they log into Gradiance and ask to be placed in your class. The purpose of this token is to protect you against a situation where random people try to get into a class without your permission. You should not, e.g., post it on the Internet, where random people can obtain it. Best is to announce it in class, or put it on a passworded site, if you have one.

### 5.3 How Students Sign Up for Your Class

Tell your students to go to the same URL that you used to create your class, either [www.gradiance.com/PH/register.html](http://www.gradiance.com/PH/register.html) or [www.gradiance.com/freeDB/register.html](http://www.gradiance.com/freeDB/register.html) in Fall 2004. You need to inform students of this URL, as well as of the *Signup Token* mentioned above. Students need to go to this page once and then use the main login screen at either [www.gradiance.com/PH](http://www.gradiance.com/PH) or [www.gradiance.com/freeDB](http://www.gradiance.com/freeDB), depending on whether they are using the premium or basic sites.

When a student logs in, they are given a screen that looks very much like the instructor's screen. The left menu contains the same options described in Section 5.1. At the bottom is a place where they can sign up for your class by entering the *Signup Token* they get from you. There is no limit on the number of students who can use this token.

At the top of the student's page is a list of classes for which they have enrolled (provided the *Signup Token*). Students can enter any of these classes, just as instructors can, although the student is given a student screen with appropriate options.