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Adding a Contributing Student Pedagogy Component to an Introductory Database Course

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ABSTRACT
An introductory database course is well established within computer science curricula. Instructors in this course are challenged to select a subset of possible topics to cover and emphasize and also to design appropriate assignments to help students master those topics. As theories regarding effective educational practice continue to emerge and become known, we also seek to invigorate our courses by including some of these newer techniques.

Contributing Student Pedagogy is an umbrella term that refers to a family of techniques that involves finding ways for students to become directly involved in the production of course content utilized by other students. Students not only make use of content provided by other students, but they come to view that content as valuable. This paper reports on initial efforts to incorporate an assignment based on contributing student pedagogy into a standard database course. Several iterations took place, with improvements made between the first and second iterations. Plans for future iterations are included and implications, not only for the database course, but other Computer Science courses, are discussed.

Categories and Subject Descriptors
K.3.2 [Computer and Information Science Education]: Computer science education

General Terms
None

Keywords
Contributing Student Pedagogy, database course design and tradeoffs, active learning

1. INTRODUCTION
Numerous Computer Science programs have an introductory database course, either required or offered as an elective. While the scope and contents of such a course is fairly well standardized, instructors still face important choice points. Commonly used textbooks, such as [1,9], run well over 1150 pages long and consist of approximately 30 chapters. Recommendations made by the authors of such textbooks suggest that perhaps one could cover the topics contained in 15 chapters, or half of these textbooks, in a one-semester course.

To teach such a course in one-quarter, as is the case at this author’s home institution, makes the selection of course content even more severe.

Experienced instructors also recognize that once course content is chosen, issues still remain. What degree of depth will students be held accountable for in each course topic? What activities will students engage in to learn material? How will they be assessed? When we successfully answer all of these questions and map out an entire course, we’re relieved if nothing else. However, when we reach this stage, this accomplishment sometimes works against us!

While all instructors refine their courses over time, many changes represent incremental adjustments. In contrast to such changes, introducing a contributing student pedagogy (CSP) component represents a more significant change. When we introduce something we’re unfamiliar with, this task quickly becomes formidable as we inevitably struggle with numerous course design choices that have to be balanced in order to incorporate our new ideas. Still, the nature of what we do demands that we continually reassess what we teach and also how we teach. This paper reports on some early efforts to bring an entirely new dimension to our database course and some of the decision making that took place in order to do so. We review some of the compromises made, present some promising early results and suggest some possible future enhancements.

2. SETTING THE CONTEXT
2.1 Course Background
We attempt to offer students a broad introduction to the database field, recognizing that in one quarter, we cannot possibly cover even half of the topics found in one of the standard database textbooks. Fortunately for us, we have for many years also offered a course directed at database system implementation and more recently, we have begun to offer a course in data mining. Having these courses available permits
us to give our introductory database course primarily a high-level focus. After introducing and motivating database systems, we cover: E-R diagrams and data modeling; assorted query languages, including relational algebra, relational calculus, and SQL; the relational model and relational design, with a focus on normalization; selected integrity and quality goals (aka constraints); transactions; DBMS programming; and the emergence of and growing interest in non-relational data and systems that support such. As time permits, different instructors try to introduce additional topics.

Historically our course has been taught primarily through lectures, with student performance measured through some number of exams. The course is an elective in our curriculum, most often taken by upper-level students. While we have never viewed our database course as essentially equivalent to an “SQL course”, we nonetheless recognized early on that our students would benefit from some type of activity that allowed them to gain some first-hand experience using SQL, both interactively and through a programming interface, as well as to carry out some form of non-trivial data modeling exercise. With this in mind, we have students complete a loosely structured, team-oriented project that involves modeling some data domain, converting their model to a well-normalized relational database, implementing that database using Oracle (more recently, Postgres), demonstrating a variety of SQL features through both an interactive interface as well as through a Java program, giving a short presentation in class, and documenting both the process and the products developed.

The database project offers students a more realistic and larger-scale opportunity to enhance their understanding of data modeling, relational design, and SQL, but the course also demands that students master a number of distinct concepts. To help students prepare for exams, we offer students a fair number of homeworks on specific topics such as relational algebra, relational calculus, SQL, basic E-R modeling, normalization, indexing, and so on. Students submit their solutions, which count a “small amount” toward their course grade, but the primary use of the homework is to guide classroom discussions and reveal possible misconceptions regarding specific topics.

While the course is “crowded” and already “packed”, it was felt that students could also benefit from an assignment that allowed them to expand the course by going more deeply into or extending a database topic not covered by the instructor, since most students do not take additional database courses. This assignment provides students with a modest opportunity to search the scholarly literature. It also provides students with an opportunity to improve their written communications and analytical skills, something that we attempt to make pervasive throughout the curriculum. This led to an assignment that required students to identify a scholarly paper on a database topic not covered in class that they would summarize and also critique. Papers must be instructor-approved; if proposed papers are rejected, then students must find another potential paper to review. Students appear to enjoy this activity, but in some ways, the instructor seemed to benefit more than the students since the instructor saw all the papers and read all of the reviews. A few years ago, one additional element was added to this assignment. Students were asked to prepare one PowerPoint slide based on their paper, which they submitted to the instructor. The instructor assembled all of the slides into a single slide show and on the last day of classes, students were given two-to-three minutes to briefly summarize key points from their paper as well as to offer their reactions to the paper. This allowed all students to gain from the work done by the other students and it provided a low-stress, enjoyable way to end the course.

2.2 Contributing Student Pedagogy

The version of the database course just described accomplishes many goals. Due to our aggressive schedule, we cover considerable content for those students who elect to take only one database course while also preparing those students who move on to take additional database coursework. We offer students a chance to engage in practical and useful activities and point the way toward resources so that once they leave the course, they will have some experience in finding additional information, should they need to. Students are given opportunities to improve communications skills, both written and verbal. In addition, students work in a group on the project and can work with other students on assignments.

Even though the database course has evolved and incorporates a number of desirable elements, we can still look for ways to increase student motivation and engagement. Numerous authors over the last several decades have championed active learning strategies and promoted a variety of techniques designed to reach today’s students more effectively. One interesting family of approaches is termed Contributing Student Pedagogy (CSP) [2,3,4,5,7]. Several of the references cited do an excellent job of connecting CSP to deeper models of learning theory and we will not repeat those discussions here. Rather, we present the definition of CSP given in [5] as well as identify some of the common characteristics that seem to go hand in hand with CSP, and then move on to how we attempted to instantiate CSP in our database course.

The authors in [5] “define a Contributing Student Pedagogy (CSP)” as:

“A pedagogy that encourages students to contribute to the learning of others and to value the contributions of others.”

This definition evolved from several other earlier works and highlights two critical aspects of CSP: (1) students become actively engaged in the production of learning materials, the delivery of instruction, and quite often participation in helping others evaluate the degree to which they understood the material and (2) students come to recognize that their own learning has benefited directly from the work of their fellow students and that this should be considered a positive outcome.

Roles of students (and the instructor) change dramatically when CSP is involved. Students are active participants and instructors relinquish some control over course decisions. Changes to roles and expectations, for both students and the instructor, are likely to produce some anxiety, which needs to be acknowledged upfront. CSP extends typical group activities by taking into account the fact that other students (in fact, all other students in a class) will be affected by the effort and results produced by each group. Measures have to be put in place that allow for assessment of group work and products produced. And, in the ideal setting, students utilize a variety of technologies to facilitate communication and collaboration and to allow instructors opportunities to monitor student efforts.
3. THE DILEMMA OF HOW TO START

Sometimes when we contemplate making a major change to a course, especially one that we’re already satisfied with, we may get “hung up” with trying to make too many changes all at once or trying to “get it right” the first time. Do we just “jump in the deep end of the pool right away” or do we first “put our toe in”? In this case, after considering the nature of the course and the environment in which it’s taught and identifying several aspects of the course that perhaps could be improved, we opted to “put our toe in first”.

3.1 Course Background Revisited

Having already set the context, we need to “drill down” a bit further into some of the operational details of the course prior to the introduction of a CSP component. The course typically meets twice per week for ten weeks, with each class lasting two hours. One more class session follows in week eleven, most often used for a final exam.

Some topics (e.g., advanced data modeling issues or normalization) in a database course typically prove to be more difficult for students than others. In order to give students sufficient time to master some of the more difficult topics, the course structure includes three exams. Each exam covers roughly a third of the course material, although the third exam also includes a few more comprehensive questions that span the entire term. Exams account for 60% of a student’s grade, but are weighed unequally so that the best exam counts for 25% while the worst exam counts for only 15%. The database project counts for 20% of a student’s overall grade, with all students within a group receiving the same project grade. The scholarly paper assignment accounts for 15% of a student’s overall grade. The final 5% of a student’s grade stems primarily from attendance and homeworks as well as the instructor’s subjective assessment of each student. It should be noted that several homeworks allow students to reflect on exams and exam grades. One homework assignment gives students a chance to review the database project, making note of their own contributions as well as those of other group members. If there is compelling and uniform evidence that one or more group members contributed very little (or a great deal) to the project, that can be accounted for through the instructor’s subjective assessment component.

It typically takes a while to cover enough topics in the course to provide students with sufficient background to tackle the database project. If they start too soon, they are likely to produce ill-conceived designs or poor implementations. Thus, the database project tends to start about midway through the course, with final materials due toward the end of the term. Likewise, the scholarly paper review also starts later in the term because students need to gain an appreciation for the topics that will be covered in class so that they can then identify papers from other topics that they might like to review. Student reviews are due at the end of the term and as stated previously, students also present their paper during the last class session. The end of the term becomes quite busy as students are busy completing multiple assignments, and the exam must be graded quickly.

3.2 First Iteration

It did not seem reasonable to add another assignment to an already crowded course. Rather, the decision was made to replace one assignment with another and then to see what further adjustments needed to be made to other aspects of the course. Given that the database project was deemed an essential aspect of the course, the decision was made to replace the scholarly paper review with a new assignment centered on contributing student pedagogy.

The most recent versions of the course made use of [9]. Chapters covered during the term included: 1 (introduction); 2 (relational model); 3-5 (SQL); 6 (relational algebra/calculus); 7-8 (data modeling and database design); 10-11 (brief; primarily for indexing); and 14 (transactions). Lectures on topics related to these chapters made use of slides (which were extensive) provided to textbook adopters, although the instructor frequently annotated the slides to highlight material or to make additional points. For some topics, separate materials prepared or selected by the instructor were provided. As previously mentioned, toward the end of the term, students were quite busy working on assignments. Time for group work in class was provided during some of the later classes and “short” introductory lectures were given on a few additional topics. These topics varied, but often were chosen from concurrency control (found in chapter 15), data warehousing and data mining (found in chapter 20), or XML (found in chapter 23).

3.2.1 The Basic CSP Assignment

Students were presented with the basic motivation and benefits for including an assignment based on contributing student pedagogy in the course. At the time the assignment was given out, there were approximately 20 students in the class and there were five groups of four students each. Since students had already been grouped for the purpose of the project, the same groups worked on this assignment. Groups were given a list containing five possible topics (with the corresponding textbook chapters): concurrency control (chapter 15); distributed databases (chapter 19); object-based databases (chapter 22); XML (chapter 23); spatial and temporal data and mobility (chapter 25). Students were told that each group would be responsible for one of the five topics. They would prepare and deliver a presentation in class and also prepare and deliver a study guide.

An initial deliverable for each group was the submission of a preference memo in which each group rank ordered the five topics and gave a rationale behind each ranking. The instructor made the final decision as to which topic was assigned to each group based on the rankings, the rationales provided, and the
order in which memos were received. Once this assignment was made, the instructor met with a representative from each group and established the presentation schedule. Each group would speak for approximately 50 minutes or half of a class session. One of the advantages of the set of topics chosen was that they were independent of one another and so the order in which topics were presented did not really matter. As an incentive for those groups that gave their presentations earlier, they were given more time to develop and deliver their study guides.

Groups were expected to prepare slides for use in their presentation and then to submit those slides to the instructor. While it was expected that slides would be submitted in Adobe PDF format, some groups neglected to do that and so the instructor made the conversion for them. Once slides were in Adobe PDF format, they were posted “as is”. Students were free to structure their presentations in any way that they wanted to, but were reminded that they had seen several models during the term. There were some lectures in which the slides provided with the textbook were used almost verbatim. At other times, the base slides were heavily annotated and in other cases, separate materials had been displayed. In fact, students were allowed to base their presentations on the slides that came with the textbook, provided that they were annotated and augmented by additional examples developed by the group. Groups were also told that they should view the textbook coverage of a topic as a “starting point”. One strength of [9] is that it contains extensive references for each chapter and it was hoped that groups would make use of these to bring additional material to the attention of the class.

Study guides were intended to serve as “high level” introductions to topics. Important terms and concepts would be defined and highlighted. Connections between the topic under discussion and the set of topics already covered by the instructor would be made. Groups could also provide advice on how to go about mastering the topic (e.g., what to read first, what examples to try, etc.). Each study guide was also expected to include a set of potential exam questions along with suggested answers. Questions could take multiple forms and students were pointed to Bloom’s taxonomy [6,8] for ways to connect types of questions with levels of expected learning. Some number of the questions provided by a group had to be original, although groups were also free to use some suggested questions provided with the textbook. Once again, study guides were to be delivered in Adobe PDF format. Once all study guides were in such format, they were posted for the entire class to view.

As a means of motivating groups to treat study guides seriously, they were told that the third and final exam would include questions, subject to editorial changes only, from each of the study guides. Thus, students could know ahead of time, a significant percentage of the last exam (i.e., both the questions and the correct answers)!

### 3.2.2 Positives and Negatives

In many respects, especially for a first pass, the assignment worked! By and large, groups produced the expected products. Most groups directly utilized and annotated the slides that came with the textbook, while several created their own slides, but based the order in which topics were addressed along the same lines as used by the textbook authors. All students in a group participated in that group’s presentation. It should be noted that as a term winds down, some students withdraw from a course. That occurred in this course and that left a few groups short a person (the instructor tried to take this into account in grading the assignment).

While students were directed to think about many issues, especially in terms of organizing material in support of desired learning outcomes and also framing possible exam questions to support those outcomes, it was not immediately apparent that this took place. For the most part, study guides were fairly straightforward, no frills documents that included lists or primarily objective type questions (e.g., multiple choice, true-false, fill-in-the-blank, etc.). Questions were also generally straightforward and reflected material that had been covered in presentations or covered in study guides. There was some, but not much evidence that outside sources had been consulted and reviewed.

As might be expected, assignment grades were high, ranging from 80 (or B-) to 92 (A). If students delivered the required materials on time and met assignment specifications, it was unlikely that much credit was deducted based on actual content or (lack of) creativity. Most deductions came from not following specifications, some oversights during presentations, or turning in items late.

In this course, exam grades typically range from 60 to 75% while project, outside assignment, and attendance/homework/subjective grades are typically much higher. The net effect is that the distribution of final course grades typically works out reasonably well. It turned out that for this instance of the course, the exam average for exams 1 and 2 was around 64% while the exam average for the third exam was around 67%. So, even by including known questions on the third exam, there did not seem to be a significant grade spike for the third exam. In addition, the contribution from the database project was slightly reduced in this version of the course and the contribution of the CSP assignment was slightly greater than that from the scholarly paper review in the original version of the course. In the end, the distribution of final course grades was as expected.

The take-away message from the first iteration was that students were willing to participate in this assignment and did a credible job with it. Presentations covered topics at a level comparable to how the instructor typically dealt with similar topics toward the end of the course. In order to accommodate the presentation schedule, the instructor carved out additional time from the course schedule (typically devoted to topics of particular interest to the instructor) and gave students a greater chance to “own” more of the course content. This resulted in a somewhat broader course, with minimal sacrifice in time devoted to foundational topics.

### 3.3 Second Iteration

There were enough encouraging signs from the first iteration of the CSP assignment that it could be used again. In the second iteration, we would strive to make incremental improvements as well as a more concerted effort to gather some direct data related to the assignment and how well it fit within the course structure.
3.3.1 The Revised CSP Assignment

In order to try and improve what groups delivered (and, hence, how useful materials would be to the other students in the class), the instructor became a bit more intrusive. Two additional deliverables were added to the assignment. Groups were required to prepare a two-to-four page outline. In this outline, groups went through their assigned chapter and identified sections they might cover or skip and which sections or topics they planned to focus on. Groups gave an initial idea as to whether they would annotate the slides that came with the textbook or whether they planned to develop their own materials. Groups had to provide a preliminary list of outside references that they planned to consult and what ideas, examples, and concepts from these outside sources they might use. Finally, groups were asked to provide a list of the main learning objectives they had in mind for their topic.

Groups handed in their outlines and then met individually with the instructor a few days later. The outline was not binding and the purpose of the discussion was to allow the instructor to comment on planned topic coverage, make suggestions with regards to learning objectives and to offer advice on various aspects of the assignment. Some groups modified their plans based on these discussions, others did not.

There were more students in this version of the class, although more students also withdrew from the course throughout the term. In order to accommodate the number of students, we started with six groups and six topics listed as possible group choices. Added to the previous list of possible topics was coverage of recovery systems (which corresponded to chapter 16 in the textbook). Groups once again delivered presentations and study guides, with Adobe PDF format versions of slides and study guides posted for the entire class to use. Questions from each of the six topics were included on the third exam in such a way that the points for any one topic accounted for 10% of the exam points. In other words, 60% of the points for the third exam came from the study guides produced by the students.

3.3.2 Positives and Negatives

It became slightly more difficult for groups to earn As on the assignment compared to the first iteration, with more grades of B or B+. This most likely was due to the simple fact that there were increased expectations and additional deliverables. The overall quality of both the presentation slides as well as the study guides increased. More groups made concerted efforts to include material from outside sources and to point students in the class to those sources. More groups opted to build their own slides and structure presentations around those topics they identified as priority topics. Study guides showed more evidence of structure and a willingness to create sample exam questions that tied in with the group’s main learning objectives.

All three exam grades were slightly higher in this iteration of the course. Exam averages for the first two exams were 70% and 69%. The third exam average was 70.5%, so once again, there did not seem to be an undue influence on exam or course grades due to the inclusion of student generated questions on one of the exams. Copies of the third exam were made before the exams were returned to students so that individual student performance on the exam could be examined.

Given the nature of the activity and the expectations for coverage of the six topics chosen, it seemed reasonable to choose primarily objective questions for inclusion on the third exam, although in some cases, some simple problems or short answer questions were also included. Five points in total stemmed from the questions chosen from each topic. Mean grades for the class on each of the six topics ranged from 3.5 to 4.4 out of 5 and the overall mean for the class across all six topics was 4 out of 5 (when rounded). The range of points students earned on various topics proved to be interesting. On two topics, the range of points was 3 to 5; on two topics, the range of points was 2 to 5; on two topics, the range of points was 1 to 5! Experienced instructors will recognize that students often surprise us on exams, scoring well in places we wouldn’t expect and doing poorly on topics we felt they probably would do well on.

When we examine how students did on the third exam on the questions chosen from their own topic, we see their mean score is only 4.1 out of 5. While a majority of students had means for the questions taken from their group’s topic greater than the overall class mean for that topic, only half of the students in the class earned all 5 points on the questions chosen from their own topic! It would seem that the approach of including student generated questions (with correct answers known ahead of time) on an exam did not unfairly bias overall course grades.

4. SUMMARY

We’ve described initial efforts to infuse a standard database course with an activity that makes students responsible for content delivery and presentation. Students research an assigned topic, prepare a one-hour class presentation on their topic, and make available to all students in the class their presentation slides as well as a study guide that can be used by all students to help them prepare for the last exam given in the class.

Students were given the option to complete a homework that allowed them to evaluate the CSP assignment from a number of different perspectives. Unfortunately (and perhaps, predictably), only approximately half the class took advantage of this opportunity, so we must temper our interpretation of the results taken from this homework. Still, it may be instructive to review some of the findings. Students strongly agreed or agreed 81% of the time that their own contributions to the CSP assignment were ‘outstanding’. When evaluating others on their groups, most of the time, students strongly agreed or agreed 63% of the time that their colleagues’ contributions to the CSP assignment were ‘outstanding’. Usually there was one individual per group who was perceived as underperforming and for that one student, ratings were much lower.

How did students feel about presentations made by other groups? On average, presentations were rated outstanding (or excellent) to good 87.5% of the time, with a range of 80% to 100%. On average, study guides were rated outstanding (or excellent) to good 87.3% of the time, with a range of 80% to 91%. Given the timing of when activities had to be completed, students probably had less time to carefully review study guides before submitting their homework, so it’s possible they did not fully appreciate whether a study guide was or was not useful in preparing for the exam. In a series of telling questions, students speculated on whether they learned more (or believed they
learned more) on a topic from the student-led presentations and study guides versus whether they had listened to a lecture, read the corresponding chapter in the textbook, and had a chance to try a homework on the topic. For three of the six topics, students strongly agreed or agreed that they learned more from other students over 50% of the time, although there were wide variations in responses. Finally, nearly 75% of those students responding indicating ‘yes’ when asked if they “had fun with this assignment”.

4.1 Next Steps and Broader Implications

We plan to maintain the structure of the basic assignment and continue to build in more support for students as they carry out the assigned tasks. More can be done with guiding students to understand the implications of Bloom’s taxonomy and how to translate that taxonomy to match up with their learning goals for selected topics. Study guides can more clearly identify individual learning goals and include questions that address those learning goals. Students also need more guidance in how to construct reasonable questions that match various levels of expected learning. Study guides can also be more direct in establishing minimum thresholds for students to reach when preparing for the exam (for example, on this topic, “you should be able to correctly answer four of the five following questions”).

Deadlines for some deliverables and assignment grading guidelines can be adjusted slightly so that virtually all students complete an evaluation (i.e., homework) related to the assignment. Having data for all (or virtually all students) in the class will allow for more meaningful assessment of the assignment and its impact on the course, especially moving forward.

Will this assignment work as well for larger class sizes or a greater number of groups in the database course? Could the assignment be extended to include an even greater percentage of the course content? For example, could groups work on two topics over the term, with feedback from their first effort folded into their second topic? A new version of the course will be rolled out next year and is likely to be taken by students who are second-year and higher. Will students with less background than students in the version of the course reported upon here still be able to handle such an assignment? As pointed out at the beginning of section 3, we eased our way into using this approach [4,5] make the point that central to CSP is the use of technology and various tools to help students collaborate, produce artifacts, and communicate with other students. We can certainly extend our assignment in this direction.

Finally, it seemed as if the database course provided a suitable vehicle for testing out this type of assignment. What was it about a database course that provided a positive level of support and can we characterize or define this more precisely to see what other Computer Science courses might also be appropriate? Informally, the database course is so broad as well as deep that it is virtually impossible to cover all possible topics in one term. There are key concepts and topics that must be covered (perhaps by the instructor), but there are a range of additional topics that allow for choice and can be covered more than adequately by students.

Individuals interested in looking at the assignment or discussing student presentations and study guides in more detail may contact the author via email.

5. ACKNOWLEDGMENTS

Thank you to students from several sections of our introductory database course who embraced the concept and willingly participated in the learning module activity. While these students learned a considerable amount and helped other students do the same, the instructor learned right along with them. In addition, thanks go to the anonymous reviewers for raising questions regarding assessment and calling for creating better measures of student learning from this assignment.

6. REFERENCES


