Personalized Attention @ Scale

Talk Isn't Cheap, But It's Effective

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ABSTRACT

Fostering an effective learning environment in large classes is a challenge: instructors and teaching assistants are stretched thin across many students, students often lack opportunities for personal interaction with course staff, and the size of the classes makes them seem impersonal. Furthermore, students in large classes can often find solutions to their labs and assignments online or copy them from other students, diminishing their impetus to learn and raising plagiarism concerns.

This paper describes our experience and evaluation of an assessment method that resolves many of these problems and appears to scale to large classes of 600+ students. Using this method, students are evaluated via a combination of automatic grading mechanisms (or clear objective rubrics) *and* a 1-on-1 "grading interview". The grading interview serves to ensure the provenance of the student's work product and their depth of understanding. This change allows us to make more effective use of peer-instruction and pair-programming in our courses. It also provides the ability to re-use assignments, the insurance of timely feedback to students, and the opportunity for individualized staff attention.

This paper describes variations on this method across numerous classes over the past seven years, some of the goals of this method, modifications and adaptations of the method over time, and the student experience of using this method based on survey feedback.

Categories and Subject Descriptors

K.3.2 [**Computer and Information Science Education**]: Curriculum; Computer science education

General Terms

Management

Keywords

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1. INTRODUCTION

The practice of Computer Science and software development has undergone a revolution in the last decade: programmers are now expected to be well versed in Agile programming techniques including pair programming and related collaborative development methods. Computer Science education is reflecting that change – early studies in the effectiveness of pair programming for introductory classes demonstrated improved student enjoyment and attainment of programming proficiency [10] and more recent studies [1, 2, 4, 5, 13] have further demonstrated that collaborative methods of learning are effective. Other studies [11, 12] have shown that these methods, coupled with peer instruction, can improve retention, similar to the impact that peer instruction has had in other STEM disciplines [7].

At the same time, the practice of teaching and evaluating student work in Computer Science classes appears to be increasingly automated. That automation has led to mechanisms to identify "cheating" in programming courses. Such "cheating" is reported as epidemic in top institutions such as Stanford [3, 8] where 23% of the honor code violations involve Computer Science students, even though those students only make up 6.5% of the school's enrollment. The University of Washington [9] finds that 1-2% of assignments involve "academic dishonesty". In part, this occurs because technology makes it easier to evaluate code and introductory Computer Science courses are undergoing incredible enrollment growth.

There is a tension in these two trends (collaboration & cheating) – what instructor has not uttered the mentally dissonant phrase "*You may work together, but you are each responsible for your own work*"? How are instructors and students to make effective use of peer instruction, pair programming, and collaboration while demonstrating their own competence?

This paper describes and quantifies our multi-year experience with one solution to this tension: interview-based grading. A core observation of our instruction method is that much "cheating" occurs because faculty evaluate ***products*** and not ***people***.

We use direct oral examination of students to evaluate understanding of the "product" of assignments. Students may work in pairs, but they are individually evaluated. These grading interviews occur weekly in our CS1 classes and transition to every 2-3 weeks for later courses. We first designed and deployed our method in a CS1 class in 2006; over time, it has been adopted by an increasing number of courses in our department and more recently has been standardized for our lower-division curriculum, including

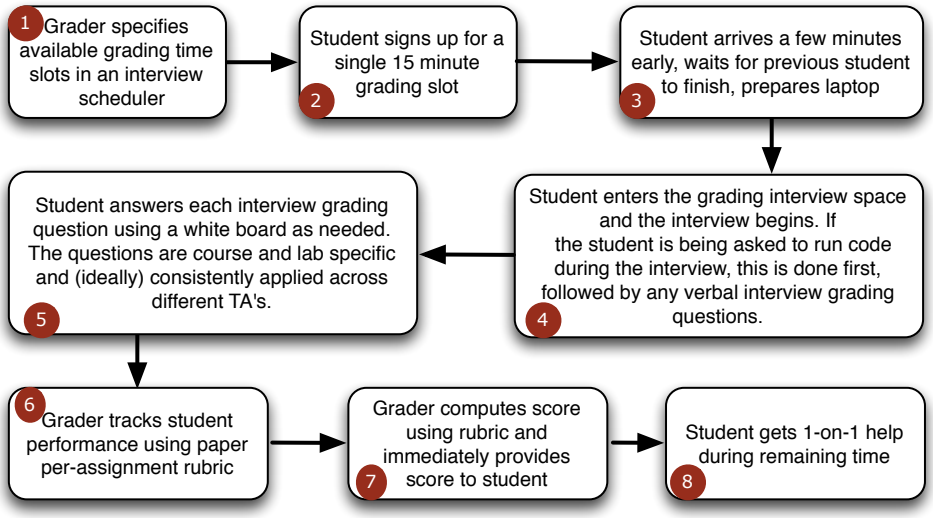


Figure 1: Grading Process

classes of 600+ students. Our initial goals were to enable the use of pair programming in introductory classes, allow other forms of collaboration such as peer instruction, ensure more timely evaluation and feedback to students, and, ideally, to improve the educational experience in an effort to increase retention.

In §2 we describe the implementation of interview grading. In §3 we review related work. In §4 we describe a survey instrument we designed to evaluate the effectiveness of this method. We analyze the results from this survey (using 600+ respondents) in §5. We describe future plans in §6 and conclude in §7.

2. INTERVIEW IMPLEMENTATION

Our interview grading process varies in detail from course to course, but the basic mechanics are standardized across all courses. Via trail and error, we have settled on 15 minute grading sessions. This means that the entire process must fit into a single 15 minute window, from the student's arrival to their exit. During this time, we generally try to ask two to four primary questions, with a variety of follow up questions to further probe a student's response when necessary. The structure of questions, and the order they are offered, is guided by an assignment-specific rubric. Although developing a rubric is time consuming, we have found that that effort can at least be amortized over several semesters since interview grading permits us to reuse material across multiple semesters.

If the student is able to answer all the questions in under 15 minutes, we use the remaining time to allow the student to ask questions regarding the topics covered in the interview and ensure they understand the material: after all, they will be seeing the same material again on the midterm or final, even if they didn't get the correct answer during the interview. Ideally, we complete all grading interviews within one week of the assignment due date. This ensures that the material is still fresh in the student's mind and helps keep the course on track and moving forward.

We have endeavored to separate *correctness* from *authenticity*. Most labs and assignments have a mechanism to report the success or failure of the assignment to the student; this is done either by a centralized auto-grading system or per-lab evaluation harnesses. Students receive a smaller percentage of their final grade for "correctness" (*e.g.* up to 40% of the total points for an assignment can be awarded for having a correctly functioning assignment) and a larger percentage (*e.g.* 60%) for the ability to explain and attest to the functioning of the program during an interview. This split of both evaluation and "points" insures that students have a mechanism for self-checking their work and also must be able to properly explain the functioning of their code to achieve a passing grade.

The 15 minute grading interview and the goal of completing all grading interviews for a given assignment within a one week window defines the lower bound on the number of interview graders (i.e. teaching assistants) per course. Our TAs are paid for 20 hours per week, but must split their time between grading, leading recitations, and other support duties. Most TAs thus have $\approx$ 15 hours per week that can be devoted to interview grading, requiring 1 TA per $\approx$ 60 students. These numbers vary a bit by course: some courses have dedicated interview grading staff that can devote a full 20 hours per week to interview grading and thus accommodate $\approx$ 80 students per grader, and some courses do not use interview grading at all, but have TAs who must spend comparable amounts of time performing non-interview grading methods (e.g. manually reviewing code submissions, etc). Most graders break up their interview grading hours into two to three hour segments spread throughout the week: *e.g.* a single three hour grading segment each day, Monday through Friday.

Figure 1 shows the steps involved conducting a standard grading interview for a given assignment.

3. RELATED WORK

There is considerable work on the efficacy of pair-programming, peer-learning and collaborative work, but there is significantly less analysis of the impact of direct oral interviews on class performance and student affect.

The most relevant study is by East & Schafer [6], who analyzed the impact of three different evaluation methods (student-initiated discussion, instructor-led discussion and in-person grading) on performance and affect in a ≈60-person CS1 class. In general, the study found no statistical difference in student grades or outcomes between the three evaluation methods, but did find that students preferred the in-person grading.

The in-person grading used in that study had a different structure and purpose from that examined in this paper. Students were evaluated in 20-minute sessions over all aspects of their work, including style, structure and correctness. By comparison, our structure uses other methods to evaluate correctness of the resulting programs and grading interviews focus on demonstrated understanding and explication of the program. Moreover, [6] did not promote pair-programming or the use of other student assistants such focusing just on the evaluation.

Surprisingly, we found it difficult to find extensive experience reports with in-person or interview grading; [6] had a similar experience. We have informally described our structure to faculty and instructors at other universities (and our own), and there was general surprise that such a method would be scalable to large 600+ person classes.

4. STUDY METHODOLOGY

We conducted a study to gain a better understanding of whether students viewed interview grading as beneficial, a hassle, or somewhere in between. We also wanted to know if we were accomplishing our goals for instituting interview grading. Namely, did students feel that they were receiving more timely feedback on assignments than they would through traditional grading?; did student feel they had permission to collaborate and research solutions to problems using outside resources?; and did students develop a deeper connection with their TAs through 1-on-1 meetings? We asked 15 questions about developing connections with course instructors, the feedback students received on interview graded assignments, and collaboration with peers and the ability to consult outside resources. For each of the 15 questions, we asked students if they strongly agreed, agreed, neither agreed nor disagreed, disagreed, or strongly disagreed with the statement presented (Figure 2).

There were additional questions on the survey asking for comments. We asked students what they liked most and least about interview grading. We also collected information on gender, year in school, previous experience with interview grading, and in which class they were currently enrolled.

4.1 Data Collection

We posted the survey on our department Learning Management System (we use Moodle) used for course management for several classes, including all lower division classes. Students were asked in the last two weeks of the semester to complete the survey. In the introductory classes, students were asked to complete the survey during their weekly recitation. They were not graded on whether or not they completed the survey, and the survey responses were anonymous. None of the questions were mandatory; students were able to answer some questions and not others. The survey was administered through the campus Qualtrics online survey system, where any student who had the link to the survey could complete it.

The survey was administered for Fall, Spring, and Summer semesters during the 2013-2014 school year to the freshman-level introductory computing classes (CS1) and data structures classes (CS2), the sophomore-level computer systems classes, and the junior-level software engineering classes. These were the classes where interview grading was being used consistently and where we believed the interview-grading process would have the most benefit for students.

5. ANALYSIS

There were 667 students who responded to the survey; their responses are shown in Figure 3. The results from the survey show that students' response to interview grading has been overwhelmingly positive. Many students agreed that being able to consult outside resources and collaborate with their peers not only increased their ability to complete their assignments, but also gave them confidence in their ability to learn new material. Many students went so far as to support the statement that the 1-on-1 connection they developed with their TA helped them to not drop the class. Comments about the feedback they received were also present in survey results.

5.1 Consulting outside resources

The strongest responses in the survey were to questions about consulting outside resources and the positive effect this had on students' ability to complete assignments, collaborate with peers, and confidently learn new material without outside assistance. In response to the statement,

> "*Having permission to consult outside people and references improved my ability to complete my assignments.*"

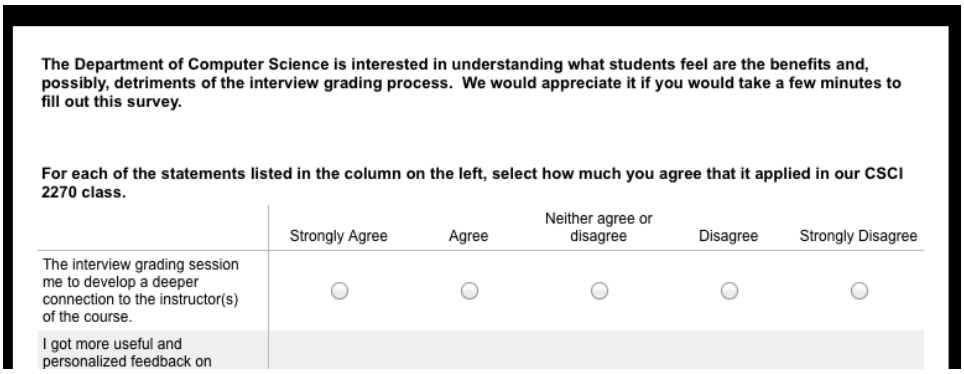
78% (521 out of 666) of respondents said they strongly agreed or agreed.

The positive effect of consulting outside resources was not limited to completing assignments. In another question, we asked students to respond to the statement,

> "*Permission to collaborate and consult outside resources has improved my confidence in learning new material.*"

70% (461 out of 663) strongly agreed or agreed with the statement. There was also a strong link between positive responses on the question about completing assignments and the question about learning new material. Of 521 students who answered positively to the first statement about collaboration, 82% also answered positively about their improved confidence to learn new material. While we believe it is important for students to be able to complete assignments, we find the improved confidence to be the larger gain, particularly for introductory courses.

In our questions about consulting outside resources and collaboration, we didn't explicitly draw the connection between interview grading and our comfort with letting students consult outside resources and collaborate. We use interview grading as a guard against cheating, and we feel confident letting students work together on assignments knowing that they will need to explain their solutions to a trained grader. Based on students' responses on the positive effects of collaboration, we feel that we have achieved our goal of encouraging student collaboration.



The Department of Computer Science is interested in understanding what students feel are the benefits and, possibly, detriments of the interview grading process. We would appreciate it if you would take a few minutes to fill out this survey.

For each of the statements listed in the column on the left, select how much you agree that it applied in our CSCI 2270 class.

	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly Disagree
The interview grading session me to develop a deeper connection to the instructor(s) of the course.	○	○	○	○	○
I got more useful and personalized feedback on					

Figure 2: Survey Format

#	Question	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly Disagree	Total Responses	Mean
1	The interview grading session helped me to develop a deeper connection to the instructor(s) of the course.	118	280	143	92	32	665	2.46
2	I got more useful and personalized feedback on interviewed graded assignments than I did on other assignments.	215	289	91	53	19	667	2.06
3	Having permission to collaborate in this class helped increase my connection to my peers.	196	207	170	62	29	664	2.28
4	Having permission to consult outside people and references improved my ability to complete assignments.	273	248	104	29	12	666	1.89
5	I think the interview grading process gave the instructor(s) a better understanding of my gaps in understanding of the material than more traditional assessment would.	180	265	122	63	33	663	2.25
6	Interview grading gave me an opportunity to discuss things with the instructor(s) that were important to me.	186	241	140	66	31	664	2.27
7	When I left interview grading sessions, I felt that I had improved my understanding of course concepts.	172	232	135	92	33	664	2.37
8	The interview grading process resulted in me getting more timely feedback on assignment submissions than I usually get in paper graded courses.	187	254	140	49	31	661	2.22
9	The interview grading session provided an opportunity for me to give feedback about the course.	97	188	205	125	46	661	2.75
10	The increased 1-on-1 contact with instructor(s) that is a part of the interview grading process reduced my intentions to drop the course.	87	130	291	94	60	662	2.86
11	The timely feedback I received on my assignments helped me stay on track with the course material.	113	241	184	95	30	663	2.53
12	The feedback I received in interview grading helped me learn the course material.	139	275	131	84	33	662	2.39
13	The interview grading process helped me understand course expectations.	135	302	139	63	22	661	2.30
14	The interview grading process has increased my confidence for doing job interviews.	85	182	231	117	46	661	2.78
15	15. Permission to collaborate and consult resources for this course has improved my confidence in learning new material on my own.	183	278	150	34	18	663	2.13

Figure 3: Survey Results for All Respondents

5.2 Student retention

We asked other questions directly related to developing a stronger connection with course instructors and in one question, asked if the one-on-one contact with course instructors reduced their intention to drop the class. Over all classes, there were 217/662 (33%) students who agreed or strongly agreed that the one-on-one interviews helped them stay in the class. There was no statistical difference in the answers in the lower division classes – of those 217 students, 74% were from the introductory course, and the other 26% were from five other courses. This matches the distribution for the students who took the survey.

For the remaining two thirds of students who did not agreed with the statement, it is possible that many of them were not at risk of dropping the class. The interview grading process resonated with some students. Of the 154 students who disagreed or strongly disagreed with the statement about dropping the class, many of them still responded favorably to statements about collaboration with peers and to statements about interview grading providing more useful feedback than traditional grading methods. For many students (291), they neither agreed nor disagreed that interview grading helped them stay in the class. These students also demonstrated a favorable response to statements about feedback and collaboration.

The answers to the question about dropping the class shows a potential limitation in our survey. Without background on the student answering the question, we don't know if they were ever at risk of dropping. They may have been at risk, and interview grading did not play a role in keeping them in the class. Or, they may have had no intention of ever dropping the class, and therefore, interview grading had a neutral effect on them in terms of staying in the class.

5.3 Timely feedback

Our questions about assignment feedback asked students if they felt they received more timely feedback, more useful feedback, and if the feedback they received helped them learn the course material. Just as with questions about student retention and collaboration, questions about feedback also received mostly positive responses. In response to the statement,

> "*I got more useful and personal feedback on interview graded assignments than I did on other assignments.*"

76% (504 out of 667) of students either agreed or strongly agreed. Students also responded favorably about how the

#	Question	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly Disagree	Total Responses	Mean
1	The interview grading session helped me to develop a deeper connection to the instructor(s) of the course.	81	113	20	2	1	217	1.75
2	I got more useful and personalized feedback on interviewed graded assignments than I did on other assignments.	113	89	14	1	0	217	1.55
3	Having permission to collaborate in this class helped increase my connection to my peers.	100	75	33	6	3	217	1.79
4	Having permission to consult outside people and references improved my ability to complete assignments.	120	79	13	4	0	216	1.54
5	I think the interview grading process gave the instructor(s) a better understanding of my gaps in understanding of the material than more traditional assessment would.	96	100	16	3	1	216	1.67
6	Interview grading gave me an opportunity to discuss things with the instructor(s) that were important to me.	97	95	20	3	1	216	1.69
7	When I left interview grading sessions, I felt that I had improved my understanding of course concepts.	97	99	16	4	0	216	1.66
8	The interview grading process resulted in me getting more timely feedback on assignment submissions than I usually get in paper graded courses.	99	97	19	1	1	217	1.65
9	The interview grading session provided an opportunity for me to give feedback about the course.	72	88	43	13	0	216	1.99
10	The increased 1-on-1 contact with instructor(s) that is a part of the interview grading process reduced my intentions to drop the course.	87	130	0	0	0	217	1.60
11	The timely feedback I received on my assignments helped me stay on track with the course material.	78	103	26	7	3	217	1.87
12	The feedback I received in interview grading helped me learn the course material.	92	105	14	4	1	216	1.69
13	The interview grading process helped me understand course expectations.	76	116	18	7	0	217	1.80
14	The interview grading process has increased my confidence for doing job interviews.	63	84	45	24	1	217	2.15
15	15. Permission to collaborate and consult resources for this course has improved my confidence in learning new material on my own.	91	96	25	2	3	217	1.76

Figure 4: Survey Results for Respondents Who Agreed or Strongly Agreed that Interview Grading Helped Them Not Drop

feedback helped them learn the course material. In response to the statement,

> "*The feedback I received in interview grading helped me learn the course material.*"

63% (414 out of 662) of students either agreed or strongly agreed.

5.4 Difficulties encountered

The most common complaints about interview grading from students were logistical in nature. Students commented that they had difficulty finding the grading rooms, or finding a meeting time that fit into their schedule. Students who did not schedule a time as soon as they were able to would find that the only remaining times conflicted with their class schedule. For the graders/TAs, this meant they had to open up more time slots or arrange a time individually with the student. With each grader responsible for 60-80 students, these scheduling issues could waste considerable time.

There was also a scheduling problem of gaps in the schedule created when students don't sign up for a time slot that is sandwiched between other selected time slots. There is not much for a grader to do with an extra 15 minutes while waiting for their next meeting, which also results in lost time in their schedule. Scheduling is not as simple as setting up time slots and having all students fit into them. There will be gaps and missed meetings that ultimately require more time from the graders.

Related to the scheduling difficulty was another issue we encountered with students not showing up for grading meeting, or showing up late. The TA still "lost" that time, and depending on the make-up policy for the class, may have to make more time for the student to make up the meeting. In some classes, the policy was for students to receive a 0 or a maximum of 40% (reflecting the "correctness" portion of the grade) for an assignment with a missed grading meeting. Unfortunately, students would still miss meeting in the first few weeks of class and then request a second chance. For introductory classes with 300+ students, these frequent emails from students asking for a makeup meeting presented a burden for course instructors.

There were also comments about TA inconsistency. Students commented that some TAs were interested in teaching, while others just wanted to get it over with and didn't take the time to explain concepts. One student commented that his least favorite thing about interview grading was "*Very inconsistent TAs. Some were very helpful, while others seemed a bit condescending.*" Another student commented that their favorite thing about interview grading was, "*1 on 1 feedback and being able to discuss the material*".

Some students, and TAs, expressed anxiety about the discourse arising from grading meetings – the social engagement exacerbated language differences or comfort levels of social interaction. We did not quantify or measure these concerns in this study, but we believe that students and TAs will encounter similar experiences in interviews, job talks, and group projects; it is unclear if interview grading presents a unique barrier for these students, and it may even help better prepare them for similar real-world social experiences.

6. FUTURE PLANS

We are working on improving our interview grading process on several levels. The first is the number of TAs required per course. Our goal is to reduce time spent on other TA duties to enable more time for grading interviews. One such method is to hire peer-teachers (termed *Learning Assistants* or LAs at our university); these are drawn from undergraduate students who have recently taken the class in question. The LAs provide direct peer instruction to the students, supplanting the traditional role of "office hours" for the graduate TA. While we are making progress by hiring extra LAs for helping students and minimizing TA prep time by having pre-made recitation/lab exercises available, our TAs still must dedicate time to a number of non-grading duties: *e.g.* handling grading issues, responding to student and staff emails, weekly meetings, and managing missed appointments. Many of these duties are communication related, and we are working to increase TA communication efficiency (e.g. using real-time communication systems like Google Hangouts instead of emails, relying on FAQs and forums to address common student questions, etc).

Another area for improvement is to find a way to make it a fulfilling and beneficial experience for the TAs. Interview grading tends to rank last amongst desired TA tasks. This is partly due to the amount of energy it takes a TA to create an effective interview, jumping from one student's submission to the next and actively analyzing their code for specific questions related to their submission. While TAs could do this prep work ahead of time, that does add extra time to their already cramped schedule, and since students often switch their scheduled grading times up until the last minute, even knowing which students to prep for can be difficult. Furthermore, the introduction of grading interviews requires our graduate TAs to consistently work the full 20 hours per week for which they are paid, something TAs often could get away without doing in less time structured, non-interview graded courses. It is also harder for TAs to defer the evaluation work when conducting interview grading (because their schedules are publicly visible), but, conversely, the instructor is more aware of any delay in providing feedback to students.

In response to the students' comments about TA inconsistency, we have added training sessions on how to effectively run interview grading meetings. We cover the logistics of setting up the interviews, what type of questions are appropriate, how to look at a student's code and question specific aspects of it, and personal hygiene (similar to rules for pair programming). This is now a required seminar at the beginning of the semester. Equally important, we have focused on more precise grading rubrics for each class so that instructors, students and TAs have a clear and consistent understanding of how students should be evaluated.

While we have dabbled in exploring interview grading for quizzes and exams, more experience and evaluation still needs to be done to draw similar conclusions in those contexts.

Overall, we have had tremendous success for students experiencing interview grading. Our department is including interview grading in more and more courses. We plan to continue using interview grading in many of our courses going forward.

7. CONCLUSION

Using interview grading as a part of our effort to foster a more effective learning environment for large classes appears to be working very well. As we have shown through our surveys, students are positive about interview grading for many different reasons including the fact that it supports an environment in which they can collaborate and use other external resources freely. They also enjoy the one-on-one time with the instructional staff. Faculty involved in with interview grading are very positive about it and find, among other things, that it increases their connection to their classes, allows them to reuse assignments from one semester to another, and find the feedback useful in gauging student progress in the class. These early results from our experience with and evaluation of interview grading lead us to conclude that interview grading is both beneficial and scalable. We will continue to refine the interview grading process and are expanding its use across a wider range of courses.

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