Student Prediction and Tracking of Learning Progress during an Assembly Language Programming Course

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Abstract

The learning curve associated with a design-oriented 3rd year course on assembly language programming and interfacing is in complete contrast to that for a C++ course. Marks are typically bimodal during the early stages of the course, but shift rapidly as the students cotton onto the material. Managing student expectations, and initial frustrations, during such a course is a challenge to the instructor. This paper discusses several process management techniques the student can use to track their own progress through any course. The techniques also provide feedback to the instructor in terms of class understanding. Tools for handling the process management techniques are illustrated.

1. Introduction

Last year I had the worse evaluation and student rapport in 20 years of teaching. Discussions with a teaching psychologist suggested that the problems stemmed from an inability to convey and manage my expectations to a large class. Three issues complicated these problems. The first factor is my style of teaching. With a background as an "experimental physicist" I teach all my courses with a hands-on approach using extensive design component in laboratories and open-ended questions in quizzes. Many 3rd year students are uncomfortable with the freedom this approach provides.

Another factor is the change from the structured high-level language programming taught to 1st and 2nd year classes to the more unstructured format and steep, initial learning curve associated with assembly language programming at the 3rd year level. Experience shows that early quizzes produce bimodal results with class averages around C/C-. This is very frustrating for students who will cotton onto the material later in the class. They can't bring themselves to believe the instructor's verbal reassurances during the term that their marks will pick up and the final class average will be B/B- or better.

A final factor in my poor evaluation was the souring of class-professor relationships because of an unintentional error generated in the answer sheet handed out directly after an in-class quiz. The exam was marked using the correct answer, causing a very minor change in the quiz mark and zero effect on the final GPA. However, that was not the manner the changes were perceived by the class.

To overcome these problems, it was necessary to better expose the students to my expectations of their performance based on previous experiences with similar classes. I also wanted the students to get a better handle on their own expectations of themselves, and me. Many of the concepts introduced can be recognized as modifications of process management concepts associated with Humphrey's Personal Software Process (PSP)[1]. The tools included methods for generating expected and planned progress, and then tracking progress through the term. Students were also provided with the tools to enable them to become more aware of, and responsible for, evaluating their own level of understanding of the course material during quizzes. As will seen in this paper, the metrics generated from the tools also provide the instructor an indication of areas where the class thinks it understands the material, but actually does not.

2. Expected and Planned GPA

The first step is to enable the students to have a realistic idea of what their progress will be through the course. This is done by generating a spreadsheet showing the class average the instructor is expecting for each course component. A tool then enables the students to generate an EXPECTED GPA based on their own performance relative to the class average in other courses. This tool is demonstrated in Figure 1.

To generate the EXPECTED GPA based on class averages, the student is requested to answer basic questions regarding their performance relative to the class during quizzes, laboratories, midterm and final exams. The example chosen is for a student expecting good performance during quizzes and laboratories, but falling apart during the major exam. This spreadsheet is a variant of the PSP Earned Value Analysis for small software programs.

This actual figure makes use of unrealistic large 20% -- 30% variations between the student predicted performance and the class average in order to show significant differences in the graph. This is because small variations in student performance on any course component have a negligible effect on the overall GPA. This spreadsheet approach can make the student more aware of this fact and reduces, but does not eliminate, the students coming around for that "extra half-a-mark" on a quiz.

Note that unrealistic student expectations are being partly managed using this tool. An estimate of the student's past personal habits is combined with the instructor's experience to produce a realistic indication of the probable range for the final GPA grade. The follow things should be drawn to the student's attention.

- There is a range of GPA associated with each predicted component mark. (The student's process is not stable).
- The final grade prediction is more accurate than individual component prediction. Fluctuations in individual performance of small course components tend to cancel out when summed.
- Future performance is similar to past performance unless changes are made in the process.

Each element discussed is related to a concept within Humphrey's PROBE approach to software size estimation[1].

Your performance during IN CLASS *QUIZZES* – Well above average 10, above average 5, average 0, below average -5, well below avera	20
Your performance during *Laboratories* – Well above average 10, above average 5, average 0, below average -5, well below average -10	20
Your performance during *Midterm* – Well above average 10, above average 5, average 0, below average -5, well below average *-10*	-30
Your performance during *Final Exam* – Well above average 10, above average 5, average 0, below average -5, well below average *-10*	-30
Your performance during *Unusual Activities* – Well above average 10, above average 5, average 0, below average -5, well below averag	10

Name ID#

PRINT USING LANDSCAPE MODE AT 75% ZOOM

Ver. 21st October 98		Expected Class Average	Rough GPA	Your Expected Mark	Probable Expected GPA
Component	**Weight**				
GPA Planning	0.01	75%	A-/B+/B	85%	A
Post Lab. 0 Quiz	0.01	68%	B-/C+/C	88%	A
Prelab Quiz 1	0.02	68%	B-/C+/C	88%	A
Lab. 1	0.03	80%	A/A-	100%	A
Post Lab. 1 Quiz	0.04	65%	C/C-/D+	85%	A
Tracking 1	0.01	75%	A-/B+/B	85%	A
Prelab Quiz 2	0.02	75%	A-/B+/B	95%	A
Lab. 2	0.03	82%	A/A-	100%	A
Post Lab. 2 Quiz	0.04	70%	B/B-/C+	90%	A
Tracking 2	0.01	76%	A-/B+/B	86%	A
Prelab Quiz 3	0.02	75%	A-/B+/B	95%	A
Lab. 3	0.04	84%	A/A-	100%	A
Mid Term	0.15	70%	B/B-/C+	40%	D
Mid Term Tracking	0.02	85%	A	95%	A
Prelab Quiz 4					
Lab. 4	0.06	66%	C+/C/C-	86%	A
Post Lab. 4 Quiz	0.03	75%	A-/B+/B	95%	A
Tracking 4	0.01	85%	A	95%	A
Final Exam	0.45	72%	B+/B/B-	42%	D
	1				
Predicted Final Mark		73	B+/B/B-	62	C/C-/D+

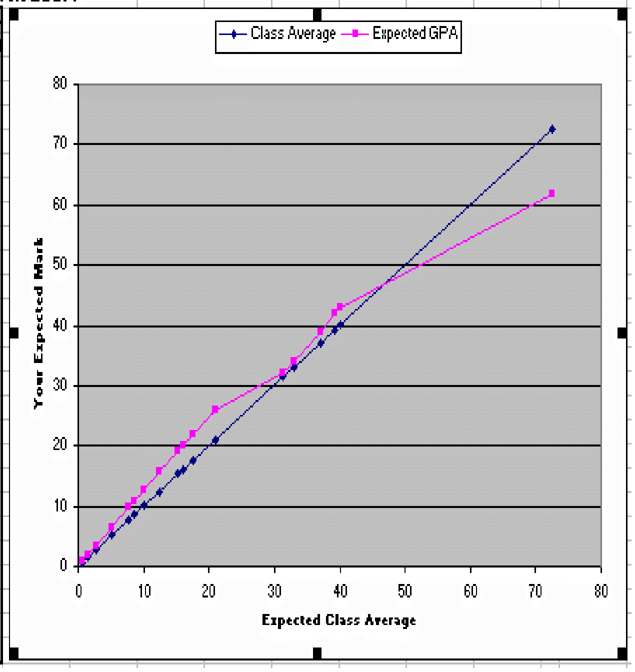

Figure 1. By answering five basic questions on their performance relative to class averages in other courses, the student can generate their EXPECTED GPA based on the instructor's concept of the relative difficulty of each course component.

The next process management step is for the student to customize the instructor's generated prediction to one that better matches their own personal or professional goals. This process is illustrated in Figure 2. Here the student has replaced the unrealistic values of 100% on the laboratories. The student has also adjusted predicted performances on the midterm and final exams, major course components, in order to obtain a desired final GPA.

The process of completing the table associated with Figure 2 can again help to manage student expectations. Changes of 5% – 10% in the mark for individual course components are possible. However students should be made to realize that changes above 15% would require a considerable change in process, and not just in effort.

Students are asked to hand in a printed version of the spreadsheet on the third class. A web-based form is used to provide the instructor with an electronic form of the data for analysis. During analysis it is useful to look for the following items

- Which students are just looking for a pass mark?
- Which students have high and realistic expectations?
- Which students have unrealistic expectations?
- What are the class expectations and capabilities viewed through their own eyes?

Ver. 21st October 98		Your	Probable	Your	Probable
		Expecte	Expected	Planned	Planned
Component	Weight	Mark	GPA	Mark	GPA
GPA Planning	0.01	85%	A	????	A
Post Lab. 0 Quiz	0.01	88%	A	????	A
Prelab Quiz 1	0.02	88%	A	????	A
Lab. 1	0.03	100%	A	90%	A
Post Lab. 1 Quiz	0.04	85%	A	????	A
Tracking 1	0.01	85%	A	????	A
Prelab Quiz 2	0.02	95%	A	????	A
Lab. 2	0.03	100%	A	90%	A
Post Lab. 2 Quiz	0.04	90%	A	????	A
Tracking 2	0.01	86%	A	????	A
Prelab Quiz 3	0.02	95%	A	????	A
Lab. 3	0.04	100%	A	90%	A
Mid Term	0.15	40%	D	60%	C/C-/D+
Mid Term Tracking	0.02	95%	A	????	A
Prelab Quiz 4					
Lab. 4	0.06	86%	A	????	A
Post Lab. 4 Quiz	0.03	95%	A	????	A
Tracking 4	0.01	95%	A	????	A
Final Exam	0.45	42%	D	62%	C/C-/D+
	1				
Predicted Final Mark		62	C/C-/D+	73	B+/B/B-

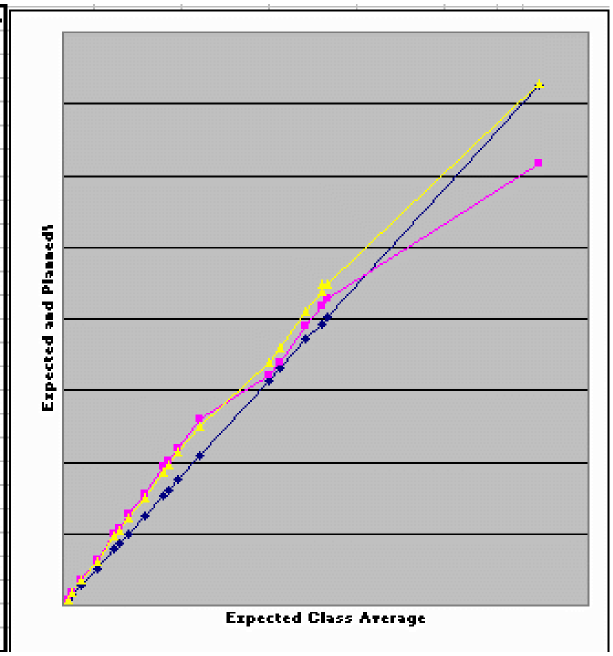

Figure 2. Using the EXPECTED GPA based on the instructor's experience and the student's past performance as a starting point, the student can adjust the needed effort for each course component to realize their own personal or professional goal.

3. Tracking Performance

Figure 3 shows the spreadsheet on actual performance that the student completes during the term. Known marks on laboratories and past quizzes can be used to up-date the process metrics after major in-class quizzes and exams. As will be shown in the next section, it is useful for both instructor and student to have a process in place that will enable the students to predict their performance on the current quiz. Marks are given for accurate prediction of quiz performance (within 10%).

The final process evaluation is done just prior to the final exam. This enables the student to play the "what-if" game by adjusting the predicted, final exam mark. This mark can be adjusted to meet the personal or professional requirements of the student. If the required adjustment is realistic, based on previous performance metrics gathered in this course, the student anxiety may be reduced. If the required adjustment is unrealistic then all that can be said is that goals have been set or expectations managed.

4. Opportunities for Mark Improvement

If you are going to make students aware of their progress through the term, then you must also allow them to have a mechanism to modify that performance. The following are some possible approaches.

- Bonus components on laboratories (up to 40%) to allow the students to explore concepts that interest them.
- Development of web-pages relevant to the course.
- The web-translation of my, unfortunately still, concrete random thought processes during lectures.

The generation of web-pages based on lectures, provided done promptly, can provide feedback on just how well the students think they understand the material. It also provides a mechanism to correct mis-understanding and a review process. For the web pages, I provide the students with an opportunity to replace their worse in-class quiz by the higher of a B- or their quiz average. Students, with a little prompting, also enjoy getting marks for learning the basics of web-page generation.

Ver. 21st October		Your	Probable	Your	Probable
		Plann	Planned	Actual	Actual
Compon	Weight	Mark	GPA	Mark	GPA
GPA Plan	0.01	????	A	75%	A-/B+/B
Post Lab.	0.01	????	A	65%	C/C-/D+
Prelab Qu	0.02	????	A	70%	B/B-/C+
Lab. 1	0.03	90%	A	90%	A
Post Lab.	0.04	????	A	70%	B/B-/C+
Tracking 1	0.01	????	A	75%	A-/B+/B
Prelab Qu	0.02	????	A	75%	A-/B+/B
Lab. 2	0.03	90%	A	90%	A
Post Lab.	0.04	????	A	75%	A-/B+/B
Tracking 2	0.01	????	A	77%	A-/B+/B
Prelab Qu	0.02	????	A	75%	A-/B+/B
Lab. 3	0.04	90%	A	90%	A
Mid Term	0.15	60%	C/C-/D+	50%	C-/D+/D
Mid Term	0.02	????	A	85%	A
Prelab Quiz 4					
Lab. 4	0.06	????	A	65%	C/C-/D+
Post Lab.	0.03	????	A	75%	A-/B+/B
Tracking 4	0.01	????	A	85%	A
Final Exan	0.45	62%	C/C-/D+	????	C/C-/D+
Predicted Fina		73	B+/B/B-	66	C+/C/C-

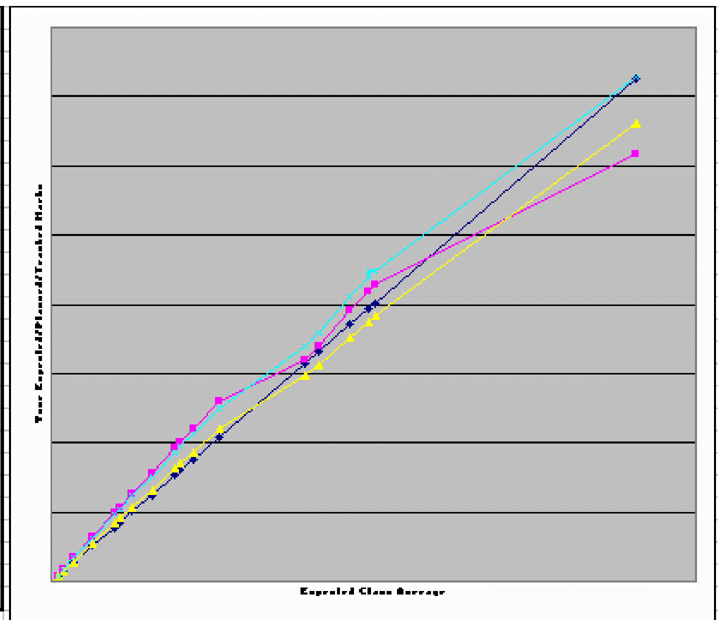

Figure 3. The student can track actual performance against planned performance in order to determine where, or if, extra effort is required.

4. Managing and Tracking Performance during Course Components

Managing student expectations through the laboratories is typically not difficult. My students typically expect, and receive, 80% (A-) or better. However, the last 20% of these design-based laboratories are directed at the better students. It is easier to convince the poorer students to go for partial marks when a process spreadsheet available. Their time is better spend demonstrating the concepts, rather than going for completion.

Managing and tracking expectations during quizzes is a little more difficult but does provide considerable advantages to both students and instructor. It works in two stages.

During the quizzes, the students are asked to evaluate how they felt they did during each question (or group of questions) on the quiz. This is an attempt to compensate for the fact that students typically come out of an exam remembering the final hard question that they did not quite manage to complete. They typically discount their performance on all the good questions.

It also provides immediate feedback to the marker, especially, as often occurs during minor quizzes, if the marker is not the instructor. If the expected mark and actual mark are widely different, then it is an indication that this particular answer should be re-examined in more detail.

A further advantage is gained by looking at the differences on a class wide, rather than individual, basis. These metrics are there to show when the class thinks it understands the concepts, but does not. This problem is indicated if many in the class predict a high mark on a question and don't receive it.

Unfortunately, given the pressures of the exam about 35% of the students either don't complete the evaluation properly, or at all. Therefore it is necessary to provide a second evaluation step, a course component by itself. Detailed answers and marking scheme are handed to the students as they leave all quizzes. My quizzes are extensive and frequent, 50 minutes in length every fortnight, and typically include one, open-ended, design question.

Students are required to go through the answer sheets to provide hard and electronic copies of their estimated mark on each question and their final quiz mark. This formalizes two frequently expressed, anecdotal concepts

- Instructor – I'll give marks if you know where you are wrong
- Student – I would have got more marks if I had the time to go over the exam.

In addition to handling student expectations prior to marking the quizzes, there are educational advantages. The students do a detailed examination of model solutions while their adrenaline is still high. Hopefully, some knowledge transfer will occur. Differences, on a class wide basis, between predicted marks and actual marks indicate where problems again exist in understanding.

5. Does Process Management Work and is it worth the effort?

I've toyed with some of these process management concepts every since I took some "Software Engineering Management" courses under the Motorola University program. However, this is the first year I've got the framework properly in place to do something closer to what I want to achieve.

It takes extra effort. You have to train the class in the process management techniques, and many don't want to learn. Then there is the extra time for the students to complete the evaluation, and you to correlate and use the results. Given that time pressure, can you really believe the results? As always, many of the students who would benefit the most from the process don't take part.

As is known from the PSP[1], studying a process automatically causes changes in it. Over the last two years, class performance in the first quiz has been much higher than predicted simply because of the fact the students were aware of the difficulty and worked to overcome it. However, the first class did poorly on the second quiz, as they no longer believed in the process.

This meant that the poorer students put in insufficient effort in preparation to overcome the poor mark predicted.

The performance evaluation during quizzes has helped me to avoid addition errors. It has made me aware of possible alternate solutions to my design questions long before student complaints come in. I've also been able to realistically consul students on their expected performance in this difficult course.

However, there are frustrations. Handing out answers can lead to lower student esteem when they don't recognize that they have provided a valid alternate form of the solution. Students also have the tendency to expect the higher end of the range of predicted GPA, despite all indications associated with the metrics of their term's performance.

Did the process management help? I had a lot more fun than I've had in many years and my evaluations went up. The class outperformed my expectations by an average of 15% leading to final GPAs predominately, and deservedly, above B+. I also suffered the ultimate insult, or perhaps the ultimate compliment. The class used my own metrics to complain about something that I had done. I did not worry too much as I could see their proposed changes did not slew their evaluation in any significant manner. Perhaps metrics are useful after all!

6. Acknowledgements

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Bibliography

[1] W. Humphries, "*Discipline for Software Engineering*", Prentice Hall , 1995

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Mike Smith is a professor at the University of Calgary, Alberta, Canada. He teaches undergraduate courses in introductory and advanced microprocessor concepts. He is continually in "acquisition mode" for equipment to update his teaching laboratories. In addition to doing biomedical and software engineering research, Mike takes his "hands-on" microprocessor laboratories and reworks them for commercial magazines such as Circuit Cellar Ink. These publications are useful resource material for students and a major reason that recent "persuasions" have been successful from Software Development Systems (U.K.), Advanced Micro Devices and Analog Devices (U.S).