
AC 2012-5176: REAL-TIME MONITORING OF STUDENT PROCRASTINATION IN A PSI FIRST-YEAR PROGRAMMING COURSE

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Abstract

Procrastination is the intentional deferment of a scheduled task and is most often attributed (by the procrastinator) to a lack of available time prior to a deadline. Although the impact of the procrastination on student learning is widely debated, it has been correlated with a lack of external (or self) regulation, motivation, and performance anxiety. These contributors stand in contrast to the commonly asserted issue: lack of time. A lecture-centric course provides limited observations for evaluating actual student procrastination. Evidence is often subjective or anecdotal. In self-paced Personalized System of Instruction (PSI) courses, observational opportunities can be further limited.

Yet PSI can be an effective teaching strategy for course material such as that in a first-year, web-based, introductory programming course. Students (particularly first-year students) have diverse backgrounds and a varied technical literacy. In this particular course, students complete 18 units following a traditional PSI s-curve (reviewed below) in terms of content difficulty over the course of one semester. The content introduces students to two syntaxes and three programming paradigms (compiled, interpreted, and object-oriented languages). The PSI format allows individuals to invest the appropriate amount of time without overwhelming new programmers or underwhelming the more experienced. Most importantly, a well-designed PSI course may instill time management skills (though often as a hard lesson learned), thus countering procrastination habits.

In this paper, we present a system developed to monitor and succinctly quantify student procrastination in real-time and evaluate its use for evaluating new course implementations, material, and instructor strategies. The web-based system uses formulated procrastination metrics to succinctly visualize student progress. Real-time monitoring of procrastination in tandem with student profile data (previous programming experience, etc.) are examined to correlate the impact of instructor encouragement, unit difficulty, external events (mid-terms, sporting events, etc.) and other activities. The system can be used to examine the collective procrastination of the class as well as individual students or demographic categories. If effective, real-time procrastination monitoring becomes another tool for objectively evaluating new strategies in a given semester also allowing for immediate adjustments benefitting current instead of just future students.

Introduction

Procrastination – in simple terms – symbolizes intentional deferment of a scheduled task. The intention to procrastinate may be an active choice or an avoidance behavior (where we choose not to make a choice). Webster's dictionary defines procrastination as “*to put off intentionally and habitually*,” which infers – debatably – that the description *chronic procrastinator* is unnecessarily redundant. While procrastination may occur for many reasons (time limitations, motivation, etc.), anxiety and a fear of failure are certainly contributors. While procrastination is

potentially damaging in most situations, it can have a profound impact in academia when students are expected to complete all course requirements on or before a common due date. This can lead to cramming and other adverse effects.¹ This problem is exacerbated for first-year students and likely contributes to the statistic that more than half of the students who drop out of college do so in their first year.² Potential negative consequences of procrastination are reduced scholastic performance, increased pressure to cheat, and stress – both physical and mental.

Most conventional courses have indirect indicators of procrastination including performance on assignments, attendance and class participation. Based on such indicators and feedback, instructors have the opportunity to take corrective measures if necessary, particularly in smaller classes where direct conversations related to this topic seem less confrontational. However, web-based PSI³ (Personalized System of Instruction) courses significantly reduce the instructor's physical presence. Even identifying procrastination becomes a challenge. To address procrastination in this environment two coupled activities were initiated relevant to this type of course: improving presence⁵ and quantitatively measuring procrastination.⁶

In this paper we briefly review PSI courses for those not familiar with the concept, our online implementation for an introductory programming course, and relevant literature on procrastination. We then document several experiments intended to evaluate how procrastination is impacted by course activities and external events. Analysis will consider procrastination relative to both time and material. In other words, for example, do students procrastinate more on harder units or earlier units? Both individual and class metrics can be visualized. Finally, we present a method for calculating procrastination metrics in real-time to better isolate any event's impact on procrastination independent of the difficulty of the material.

Personalized System of Instruction: Philosophy and Course Implementation

The Personalized System of Instruction (PSI)³ is a teaching methodology that roughly adheres to the following principles and methodologies.

- Students learn material and only take tests when they feel ready. Each student invests the appropriate amount of time given their specific capabilities.
- There are no scheduled exams. Evaluation is based on unit/module proficiency tests. Students must demonstrate mastery of a given set of material (module) prior to studying the next module.
- Lessons are typically tutorial rather than instructional thus encouraging students to learn by doing.
- Facilitators (instructors, TAs, tutors, etc.) are routinely available to answer questions allowing one-on-one learning sessions are available to those who need additional help.
- Typically, tests are graded in person. This allows students to receive directed feedback as well as provide the grader the opportunity to evaluate a student's knowledge beyond the tested material.
- Students earn a mastery grade (A) if they complete all units in the course, or must retake the course if they do not.

The difficulty of modules in PSI courses ideally follows an S-curve⁴ as shown in Figure 1 that conceptualizes student progress through the course material (considered as a function of amount and difficulty) relative to each unit.

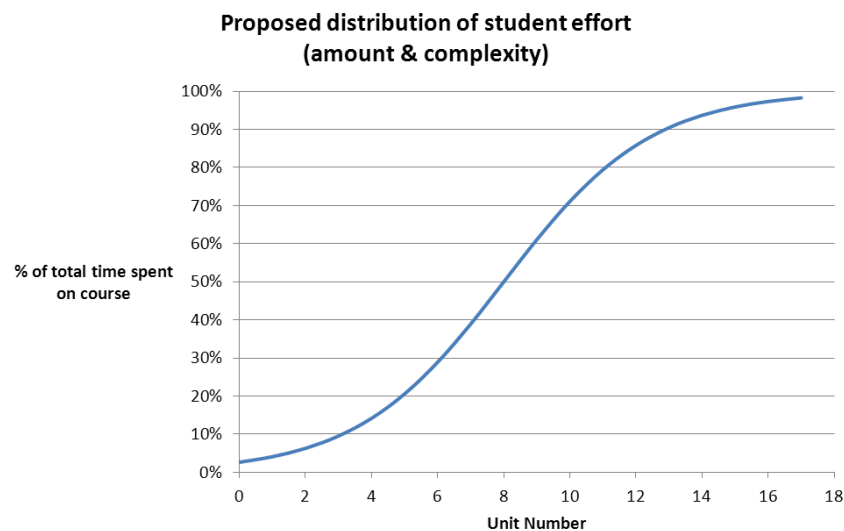


Figure 1: S-curve illustrating the ideal content difficulty in a PSI course

Thus the more difficult material is typically taught in the middle of the course. Early material can be rapidly absorbed initially as students review fundamental principles, high level concepts and complete motivating examples. Progress slows as students work through more difficult material and then speed up again as the summation of the recently completed material is collectively applied to yield more satisfying results and return the student's focus to the bigger picture. This approach additionally prevents students from becoming too discouraged early in the semester or overly anxious near the end.

The PSI philosophy is well suited for a first-year course in programming.⁷ In this particular course, students are exposed to three important programming concepts. C++ is used to introduce compiled languages as well as programming fundamentals. The interpreted language MATLABTM is then presented which also exposes students to a second syntax. The modules then return to C++ to introduce the concept of Object-Oriented Programming (OOP). Since these software tools are used throughout their collegiate curriculum, it is important that students obtain a nominal level of programming proficiency. In the long run, student anxiety is reduced when the need to learn a new syntax inevitably arises.

A quick review of the specific course implementation will simplify discussions below, but the proposed metrics are applicable to any PSI course. The course is ME205: Computers and Programming offered to first and early second year mechanical engineering students at the University of Texas at Austin. This course contains 18 modules and the course web site is shown in Figure 2. The web site was developed using the Drupal Content Management System¹⁸ but can be adapted for other courses.⁴ Students log onto the web site with their University ID. Unit 0 is an orientation module that familiarizes students with the site layout and test submission system.

It is the only module completed during a scheduled orientation period and is designed to alleviate procedural anxieties and allow students to meet the instructors and other facilitators.

COMPUTERS AND PROGRAMMING

COURSE PHILOSOPHY HONOR CODE SYLLABUS TA PAGE OFFICE HOURS FAQ'S RESOURCES

Countdown to the due date: 0 days, 0 hours, 0 minutes

2011FALLTEST

- My account
- Getting Started...
- Moving Along...
- Test Center
- Log out

UNIT PAGES

- 00
- 01
- 02
- 03
- 04/S1
- 05
- 06

TIPS FROM THE TAS

Posted Wed, 10/12/2011 - 14:34 by r

Good afternoon all,

At the **mid-point in the semester**, I asked the TAs for their tops tips - the ones they have shared the most in the last month. Here they are.

- Use the UP arrow** at the command prompt. Many students still type all their commands in at the command line. We point out to most students in OHs that the UP arrow lets you scroll through commands you have already typed. Try it out! This is not the only short cut from the command line you can find, but it is certainly a useful one.
- Read your compiler errors.** Notice first they give you both the line and column number for every error AND that notepad++ (and most other editors) show the line and column number at the bottom of the text. Finally, the error may look technical, but every error code has a description and these will tell you what the compiler thinks may be causing your errors.
- Give your variables good names.** You may be able to remember a, b, c, etc. for a few minutes, but students often confuse their declarations between two test programs OR forget when it is time to fix a correction. Using iInput instead of 'n' can help you avoid these problems.
- COUT is your friend.** Don't know what is going on in that FOR loop or function? No problem. Add a couple cout statement to print the iterator value and other useful data to the screen. Don't guess what your program is doing, actively find out what your program is doing.

I certainly hope these help out. The pace car is now between units 8 and 9. If you haven't reached Section Test #2, now is the time to play a little catch up!

Good luck, Dr. Pryor

ORIENTATION SLIDES ONLINE

Posted Tue, 08/30/2011 - 14:43 by

Good afternoon all,

We have completed 5 of the 8 orientations, and it is great to see many students already working through the units. Just a couple quick announcements:

- Office hours will officially start this Friday. See the Office Hours tab above for more details.
- If you missed your orientation for any reason, please attend one of the remaining orientations.
- You can download a copy of the orientation slides from today [here](#).

Figure 2: Home page for example student currently on Unit 6.

Specifically, units tests can be completed anywhere and proctors grade them online typically within 24 hours of submission. Units 1-3 familiarize the student with the compiler, declaring variables and interacting with the user via a terminal window. Unit 4 is a comprehensive section test (S1) taken in person during the scheduled office hours. This helps ensure the course is completed in good faith. Students must pass a Q&A interview session after each section test. More importantly this provides the grader the opportunity to give directed feedback. Section 2 (units 5-8) cover more advanced C++ programming concepts. Section 3 (units 10-12) introduce MATLAB™ and the final section (units 14-16) introduces Object Oriented Programming. The final section test (S4) must be complete by the last day of the semester or students receive a failing grade and must retake the course. All tests must be completed and submitted within 2 hours after starting.

This implementation has helped meet the requirements and address student diversity issues. Novice programmers have the flexibility to absorb material at a slower pace while experienced “gurus” can progress much faster or attempt more challenging exercises. The pass rate

consistently exceeds 80% per semester. However, procrastination is a significant issue for both novice and experienced students. Student procrastination creates several challenging problems this research hopes to alleviate.

- When students complete a disproportionately large portion of the work in the last month, there is an excessive burden on university resources and course facilitators.
- There is doubt that students who must rush through the units will retain the material or take the time to pursue their own inquisitiveness.
- Students do not receive the same level of attention from facilitators when they must grade 30-50 tests/day compared to 5-10 tests/day earlier in the semester.
- Procrastination has been cited as a reason for cheating when students are confronted with plagiarized work.
- Students do not spend as much time studying the material. A reason often cited for repeated failures in a single module is a desperate attempt to learn the material while taking a test since they procrastinated too long to budget time for practice and study.

It is our hope that quantified procrastination metrics allow instructors to evaluate the effectiveness of new course strategies designed to combat these issues. The next section offers insights into predisposition towards procrastination in the traditional form and confirms the notion that there are negative consequences.

Procrastination in the literature

Many researchers have spent considerable resources identifying the cause of (and cures for) procrastination. Dietz *et.al.*⁹ associated procrastination with individual values and learning routines, asserting that people who plan their daily activities procrastinate less than those who do not. Akinsola *et.al.*¹⁰ observed a positive correlation between procrastination and achievement in mathematics, but went on to conclude that varying levels of procrastination (low, moderate and high) have no significant impact on overall academic accomplishment and that gender played no role in procrastination-related behavior. Senecal *et.al.*¹¹ attempted to correlate student procrastination with individual motivation and concluded that academic procrastination is associated with anxiety, depression, and low self-esteem. In contrast to Akinsola, they found statistically significant differences between genders and that procrastination has a detrimental effect on GPA. It is unclear if these differences arise due to differing methodology or difference in the studied student populations. Pryor *et.al.*⁶ examined procrastination with respect to the data types shown in Table 1. Although weak correlations were found with respect to GPA and number of students enrolled, no strong correlations were identified.

Table 1: Data Types in Student Profile

High School Data	College Data	Binary Correlations of Interest
High School Rank	Semester GPA	Long vs. Short Semester
High School GPA	Overall GPA	Top 10% HS Class Rank vs. Not
SAT Verbal Score	Number of hours enrolled	First-year Student vs. Not
SAT Quantitative Score	Semester enrolled (Fall, Spring, Summer)	Transfer vs. non-Transfer

Pryor *et.al.* then looked to see if selected policies that had varied in previous semesters had an impact on procrastination. The data for this study was historical so only previous policy differences could be examined which are listed below.

- **Increased office hours** – Limited office hours may complicate schedules and fail to instill urgency in students who see a closed, unmanned office during their daily routine.
- **Increased lab space** - Students tend to work in groups and thus need access to more computing resources when in groups. This is similar to the instinct that leads us to the crowded (but not too crowded) restaurant.
- **Incentive dates** – In some semesters, students were allowed to skip one of the four questions on unit tests IF they took the test by a given date.
- **Dynamic vs. Stale Content** – Web-based instructors may work very hard to set up the course and only to then leave the content static creating a lack of presence and urgency.
- **Urgency Role Models** – Ungraded tests languishing in the proctors queue and errors in course content left uncorrected show a lack of urgency in the instructor that can be picked up by the student. Semesters with shorter grading times may decrease procrastination.

The results showed that increased office hours, dynamic content, and prompter grading all had a positive impact and incentive dates had only a slight impact. This may have been due to a student's failure to meet an incentive date was perceived as a reason to no longer self-regulate. Increased lab space had no impact on completion rates, but had other, obvious positive benefits.

Elvers¹² examined the effect of dilatory behaviors on student performance in both traditional lecture-oriented and online courses and found similar correlations between student satisfaction, procrastination and exam scores. After conducting student interviews, Schraw¹³ concluded that laziness, fear of failure and postponement were the primary causes. They additionally asserted that teacher expectations and lack of incentives were perceived to influence procrastination, but that grades were not affected. Hsin¹⁴ introduced the concept of *active procrastinators*: students who deliberately work under pressure and produce similar output as non-procrastinators. Empirical evidence suggested that active procrastinators do better than “conventional” procrastinators. However the literature¹⁵ has more recently emphasized the distinction between procrastination (with all the potential harm the term symbolizes) and simple but scheduled delay.

This review focused on identifying the high-level sources of procrastination and identifying existing methods of quantifying procrastination. The multitude of papers (^{16,17}, for example) that comment on procrastination for a specific course are not reviewed here, but it is clear that many curricula developers identify reducing procrastination as an important objective in their efforts. Additionally, while some papers listed above subjectively categorized levels of procrastination, no quantifiable metrics beyond those developed by Pryor *et.al*⁶ were identified.

Summary of time domain procrastination metrics

This section summarizes the metrics developed by Pryor *et.al*⁶ and discusses their viability relative this effort's objectives. It also introduces a new metric to quantify procrastination relative to content instead of time. The mathematical bounds for each formula are also presented. Note that each formula attempts to quantify the procrastination of a specific student *i*. These

values can then be averaged to determine an overall metric for a set of students. Note, there are 18 total units where 4 are sections test (S1, S2, S3, and S4) in this particular course. Some of the metrics below assume this format for clarity, but the proposed metrics are generalizable. In the formulas below D_{event} refers to the day of a particular event and n_i refers to the i^{th} unit. The value R_o symbolizes the completion rate for an imaginary “pace student” by calculating the number of days spent on each unit if all units are studied for equal amounts of time for the entire semester. For example if a semester contains 95 days, each unit of the 18 units would take approximately 5.25 days for a pace student to complete.

Margin of Safety Metric (MoS) - The MoS metric is the ratio of the 4th and final section test (S4) submission date and the last class day D_{sem} . **MoS** is motivated by the scenario where a student writing a paper several weeks early but waits until minutes before class to print it out and turn it. More generally MoS defines “robustness to last minute complications.”

$$0 \leq MoS_i = \frac{D_{S4}}{D_{sem}} \leq 1 \quad (1)$$

Advantage(s): Focuses on the final result and quantifies when students actually finish. It addresses the fundamental risk that leaving even small tasks to the last minute can lead to failure.

Disadvantage(s): Does not account for differences between students finishing on the same day but one methodically progresses through the material while another completes most units in the last few weeks. Metric can only be formulated for students who have finished the course.

Pacing Metric(s) (PM)- Pacing metrics look at intermediary milestones as well as the finish date. First consider only a student’s S2 (about 50%) completion date relative to their finish date.

$$S2_i = \frac{D_{S2}}{n_{S2} \times R_o}; S4_i = \frac{D_{S4} - D_{S2}}{(n_{S4} - n_{S2}) \times R_o} \quad (2)$$

Metrics can be formulated by then looking at the ratio between intermediary and final milestones. Normalization is relative to the “pace student” instead of the last day of the semester.

$$PM_i = \frac{S2_i}{S4_i} \quad (3)$$

Advantage(s): Provide some insight into a student’s overall study habits. Any unit (or units) can be used to formulate a pace metric.

Disadvantage(s): Does not provide much insight into the actual effort of the student as students first learning to program may struggle early and then perform better once the fundamentals have been absorbed. It is difficult to compare values between semesters of different length. Metric only formulated after the student finishes.

Cumulative Days to Completion (CDC) Metric - The previous metrics are not indicative of behavior during the semester and could not be used to quantify short term impact of class events (such as Spring Break or a motivational email from the instructor). For the CDC metric, we sum the days elapsed from the start to the completion of *each* unit.

$$D_{tot} = \sum_{i=1}^{n_{tot}} D_i \quad (4)$$

In order to compare values at different times, the metric is normalized using R_o . Thus values closer to 0 are associated with reduced procrastination. Note that the subscript ‘ i ’ refers to the unit and CDC_j is formulated for each student j .

$$CDC_j = \frac{D_{tot}}{D_{tot, R_o}} = \frac{\sum_{i=1}^{n_{tot}} D_i}{\sum_{i=1}^{n_{todate}} (i \times R_o)} \quad (5)$$

Note that n_{todate} must be set to the number units that would be complete on the date the criterion is calculated by the pace student.

Advantage(s): Provides a normalized, real-time and comparative evaluation of procrastination.

Disadvantage(s): Care must be taken to ascertain the physical meaning of a change in the metric’s value in a given semester. The CDC for the entire course will contain discontinuities when students add or drop the course. Changes in this metrics value may be due to the relative difficulty of the units currently underway and or caused by external events.

This last disadvantage is worth examining in more detail as this is the only metric presented that is compatible with real-time analysis. Cause and effect may not be simple to determine.

Material-based procrastination metric

Recalling the typical PSI s-curve shown in Figure 1, we would expect students to not only take longer during units 6-8 (in this particular course) but also procrastinate more if difficult material produces additional anxieties that dampen motivation. Thus, we propose an addition metric to examine procrastination relative to content instead of time.

Delta Module (ΔM) Metric – This module simply looks at time elapsed between two modules.

$$\Delta M_{n,i} = D_n - D_{n-1} \quad (6)$$

The values D and n again stand for the day and unit number respectively. We note that summing this criterion yields 17 criteria values for each student. The average of all values for a given unit would then show the average time spent on each unit by the students.

Advantage(s): The comparison of each unit’s ΔM yields information with respect to the relative time spent on each module. If other procrastination affects could be normalized or neglected, these values could be used to analyze content distribution.

Disadvantage(s): The final value may have little correlation to time actually spent on a given unit. Students may be more engaged by more difficult material spending longer hours over fewer days. External events may statistically impact certain units more than others. For example, Spring break may occur when more students are working within a certain range of units. Mid-

terms in other courses may adversely impact the time committed to units in the middle of this course. Changes in this metrics value may be due to procrastination behavior independent of course material. If so, we should see the values grow increasingly shorter for later units.

Real-time analysis of the impact of external events on procrastination

Based on the summary above and the lessons learned from the literature we evaluated the use of the CDC criterion to identify the real-time impact of select external events on procrastination. If even minor events are perceptible in the results, then the CDC may be a useful tool not only to evaluate student progress and compare policies, but also a motivating factor for instructors striving to maintain a nominal value during the semester.

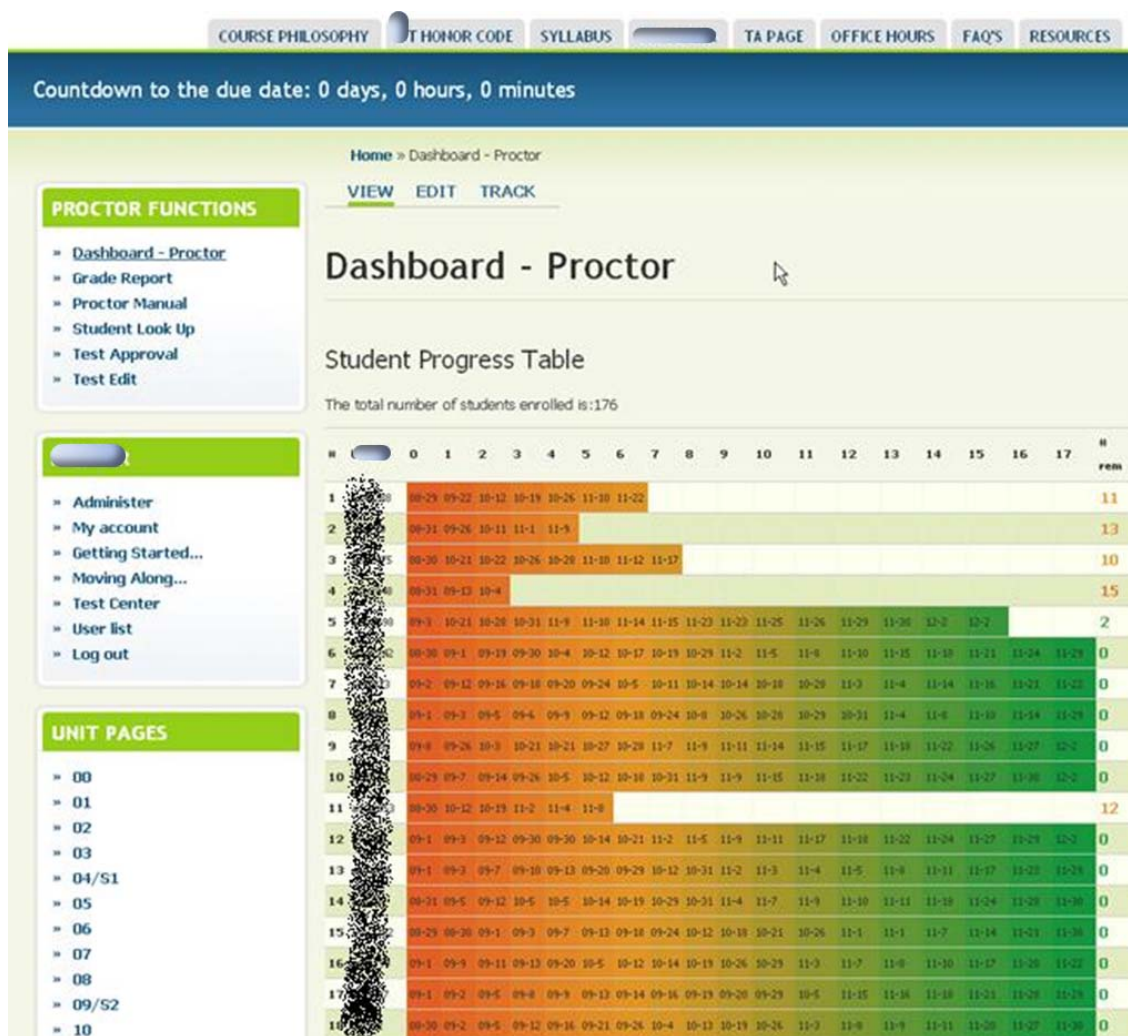


Figure 3: Proctor dashboard showing test completion dates for each student

The results of the following procedure are presented in this section.

- Calculate the ΔM for all modules to determine if there is a need normalize the CDC metric relative to specific modules.

- Calculate the CDC metric for each day during the course of the semester.
- Identify impacting events (emails from instructors, last office hours before a long holiday, etc.) that are (or are notably not) associated with dramatic changes (if any) in the CDC while keeping in mind the work by Pychyl¹⁵. A student's choice to delay work (say, to attend a Football game) is different than procrastination, but both may complicate course completion rates and resource allocations as described above.

The semester examined started on August 29th with 176 students enrolled. All material has to be completed in 95 days before the last day of the semester (December 2nd). The completion dates for each student are updated in real-time to a *dashboard* visible only to instructors (Figure 3).

This screen capture was taken after the semester and shows the dates each module was completed. Procrastinators typically fall into 4 categories: 1) those who finish the last week or day 2) those who try to finish but run out of time 3) those who start late and then stop trying in the middle of the more difficult middle units, and 4) those that never really get started.

To simplify the calculations and analysis, all instructors agreed to grade tests within 24 hours and achieved this goal over 98% of the time. The database contained 3,774 tests at the end of the semester. The ΔM for each unit is shown in Figure 4.

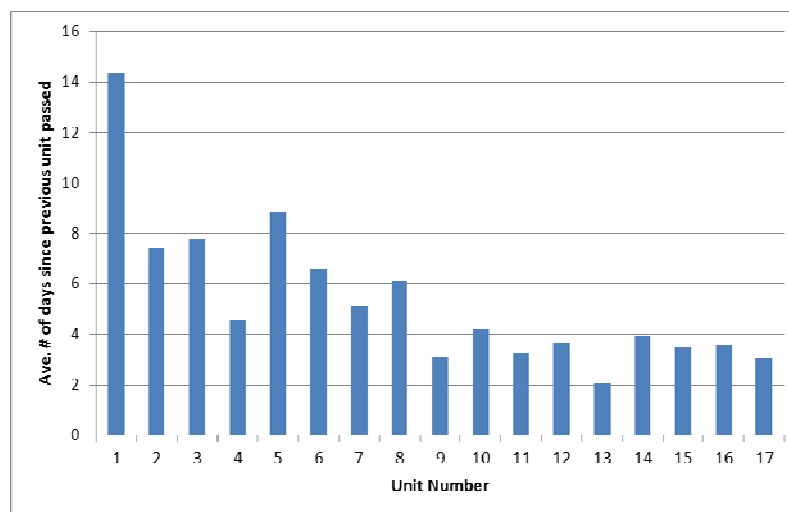


Figure 4: Average ΔM for all students who completed given unit.

These results show that the ΔM metric appears to be dominated by procrastination in time more than any other issue since the time to complete each unit tends to decrease over the semester.

One notable exception is the jump for Unit 5. One possibility is students relaxing after completing their first Section Test (Unit 4). Another possibility is unit 5 begins the climb up the S-curve (Figure 1) when control structures are introduced. Students adjust to the increased difficulty during Unit 5. In either case, there are no indications from the ΔM metric that the CDC metric needs to be normalized relative to unit difficulty. The CDC results are calculated from the data set and shown in Figure 5.

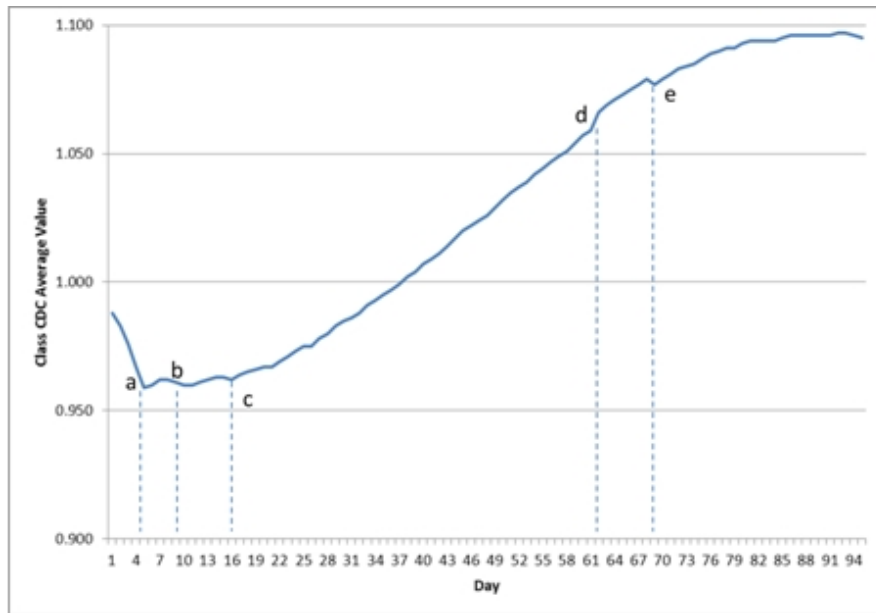


Figure 5: CDC values for examined semester.

Note the non-normalized CDC value for the pace student that completes a test every R_0 days is 902. Thus, for example, a student who works at the pace, but then completes the last 4 units on the same day (about 20 days ahead of schedule) would have a non-normalize CDC value of 862 and a normalized 0.95. Therefore even small changes in the normalized CDC average value for entire class may represent identifiable events occurring during the course. For example **Event a** occurs on Friday. Thus the dramatic upswing after this point occurred when the weekend interrupted orientation sessions where students complete Unit 0. **Event b** approximates the resumption of the few remaining orientation sessions. **Event c** identifies a small downtick on day 16 (Tuesday, September 13th). No office hours were held on Mondays this particular semester, so this date was the first realistic chance for motivated students to take the first section test. **Events d** and **e** (Friday, October 28th and Friday November 4th respectively) represent the beginning of an uptick and an apparent correction about a week later. One possible contributing event is the popularity of Halloween in our city followed by a scramble to make up for the delay. Proctors also graded during Thanksgiving weekend allowing many students to make regular process and the holiday time is not apparent on the graph above.

Individual CDC graphs for students are more telling, but similar information could be garnered from less complicated graphs. Daily CDC results were not stored for individual students, but are easy to calculate from the records for the last day. Of those who completed the course, the lowest (best) CDC was 0.336. This student completed the course on October 19th. The highest value was 1.686 earned by a student who completed 5 units the last week of class. Thus the CDC can vary significantly from student to student. It is additionally important to note the physical significance of any change in the class's overall CDC value. A change of 0.005 represents 4.5 cumulative days for every student in the course. Even this small change can significantly reduce the imbalance of resources between the beginning and end of the semester so the strategies that even slightly impacting CDC could prove worthwhile.

Conclusions

This paper assessed the viability of metrics derived from system monitor data (dashboard) to succinctly quantify student procrastination in real-time. Candidate metrics were reviewed and an additional metric was developed to quantify procrastination relative content instead of time. The Cumulative Days to Completion (CDC) metric was selected for course evaluation since the value was physically meaningful at any time during the semester. Course averages for the CDC were discussed in depth, and its ability to quantify impact was evaluated. We conclude the metric can be used to evaluate instructor strategies, course policies and the impact of other external events. It may prove useful to scale the CDC value or more explicitly formulate it to represent its physical impact. Given these tentative, but promising results the next step is the visual implementation of the metric into the dashboard as well as the development of an integrated approach for documenting internal and external events for easy archiving and inspection.

We recognize these metrics cannot tell us directly why students procrastinate or – if semantics dictate – distinguish between procrastination, deferment, or scheduling issues. One area of future work under consideration is customizing student surveys after each module to discern this data from the student. The survey questions could be modified to for students either rapidly or slowly completing different units. Such questions, could prompt students to reflect on their own with respect to their pace and potentially self-improve behavior. It additionally could help course developers to generate a more complete picture of student effort and improve course content.

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