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cstrothman@southern.edu

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PROJECT GRADEUP V2

by

Christopher Strothman

A PROJECT DEFENSE

Presented to the Faculty of

The School of Computing at the Southern Adventist University

In Partial Fulfilment of Requirements

For the Degree of Master of Science

Major: Computer Science

Under the Supervision of Scot Anderson, Ph.D.

Collegedale, Tennessee

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PROJECT GRADEUP V2

Christopher Strothman, M.S.

Southern Adventist University, 2020

Adviser: Scot Anderson, Ph.D.

The university classroom has greatly evolved from a simple syllabus and class meeting times to online documentation and virtual classrooms. These developments have changed the way students review their grades and balance their workloads. With the plethora of new technologies, students are often burdened with a full school schedule, work and social events, with few tools to help them effectively understand their grades or manage their time. Moodle did not present data organized in a way that allowed students to easily comprehend their past performance or up coming work load. GradeUp v1 added a plugin to Moodle 2.x to visualize progress-specific information that is comprehensible at a glance. Rebuilding GradeUp in v2 restores students' access to this information in Moodle 3.x.

GradeUp v2 provides visualizations so that students can answer the following questions: 1) What have I completed, and what do I have left to complete? 2) What is my current grade and projected grade at my current pace? 3) Given what I've done so far what is the best possible grade I could get if I ace the remaining work? 4) What if I stopped now, what would my grade be? 5) How am I doing compared to the average in this class? 6) If I got a particular grade(s) on a specific assignment(s) how would that change the answers to the preceding questions? 7) Where is the work left concentrated in the temporal domain? 8) When should I start working on the items left to complete in my course(s)?

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Chapter 1

Introduction

Schools today increasingly use Learning Management Systems (LMS) to manage and teach their classes. These Systems enable professors to collect data on individual student performance, and better understand their class performance as a whole. Students using these systems can gain valuable information from the data collected, if it is presented to them in a useful format.

In particular, students want a grade progress visualization that shows their current grade and projected possible grades under various what-if scenarios. Students also want to be able to see study times for their classes to enable them to plan their studying more effectively and efficiently. We have found four existing Moodle plugins that attempt to generate this type of information.

The first plugin is called Grade Reports: Quiz Analytics. This plugin generates analytical graphs using quiz data from student attempts. Over time this plugin helps to give students a better understanding of where they are struggling on quizzes and tests in a specific class as well as how they are improving over time [1]. Unfortunately, this plugin is primarily useful for classes with a high number of quizzes, and is not overly useful for classes without them. In addition, this plugin

does not provide students with a forecast of how they will perform in the future based on past results.

A second solution is a plugin called Grade Reports: Grade distribution. This plugin helps to visualize the current grades of all students in a course. This plugin is aimed at course instructors with helping to visualize the current status of their class, as well as each student's positioning in the class. It also provides feedback on changes to letter grade boundaries for professors who want to experiment with different values[2]. While this plugin provides visual feedback to an instructor, it does not provide any information on how a student might improve his grade or where a particular student might be struggling.

Another grade report plugin called Multi Course Grader Report works similarly to the Grade Reports plugin but provides grade data for multiple courses [3]. But similarly to Grade Reports, it does not give any relevant data to students to help them develop a plan to improve their performance.

There is also a fourth solution that was created by Williams [4]. Williams developed two new visualizations for Moodle 2.9. The first visualizes grades and assignments similar to burn-up charts used within software engineering. The first visualization shows students instant feedback and projected information about their current grade as well as potential grades within a class. The second visualization shows workloads over the course of the semester across individual and all classes. These two visualizations only work for older versions of Moodle and need to be re-created to work with current Moodle versions. This project updates and improves on the work of Williams [4].

Our work updates the existing functionality in GradeUp v1 to be in compliance with Moodle version 3.8. We believe this software could be invaluable to students with heavy workloads as it empowers them to make critical decisions in planning

their semesters. Using our tool, students can plan when they need to work on specific projects or assignments to avoid overloading themselves at any time during the semester.

Chapter 2

Background

There are several learning management systems other than Moodle that also have functionality similar to what we are proposing. Canvas and Blackboard are both learning management systems that have functionality allowing students and instructors to project grades into the future. Most notably, Canvas has a built-in feature known as a "what-if Score". This feature allows students to enter a score for any assignment and see it's affect on their grade [5]. Blackboard has a similar feature called Blackboard Predict, which assists professors by highlighting at-risk students, as well as provides projections for students on their progress and grades[6]. While these systems are each useful, our proposal brings these features to the open source Moodle community, which enables the benefits of such as system to affect as many students as possible.

Moodle is a web-based open source Learning Management System(LMS) designed to provide educators, administrators and learners with a single robust, secure and integrated system to create personalized learning environments[7]. Moodle is the largest LMS's in use today with over 90 million users around the world[7]. Moodle is used by both academic and enterprise environments which

helps contribute to its widespread use. Because Moodle is completely free and open source, it is constantly evolving and being improved upon.

Moodle's core functionality does not have the features we propose, however programmers may easily modify Moodle with plugins and add-ons. Moodle is primarily written in PHP, and designed for use on privately owned servers. This design means users may deploy Moodle for small projects or easily scale up (or out) to meet the needs of larger organizations.

Moodle plugins are the core of what makes Moodle such a great platform. Moodle currently has over 1600 plugins contributed by over 900 different developers. These plug-ins add all sorts of functionality such as: PayPal integration, E-Voting, Multi-factor authentication, offline quizzes, and much more. In total, there have been over a quarter million plugin downloads of different plugins all being used in learning environments. To facilitate these plug-ins, Moodle has an API for developers to use when developing plugins, as well as a wealth of documentation guidelines on their website [7].

GradeUp v1.0 is a plugin written by Dalin Williams, a former School of Computing CS Masters graduate, in 2015. GradeUp was developed as a Master's project to help students plan out their semesters based on class work load and their current grades. GradeUp has two major parts: a grade projection burnup chart and a workload heatmap. These two charts/graphs were developed to give students tools to better plan how they should study for and work on their homework throughout the semester.

The burnup chart portion of this project allows the user to view several pieces of data simultaneously. These pieces of data answer several questions for the user such as "What is my current Grade?", "What is the best possible grade I can achieve?", and "What grade will I have if I stop doing anything for this class?".

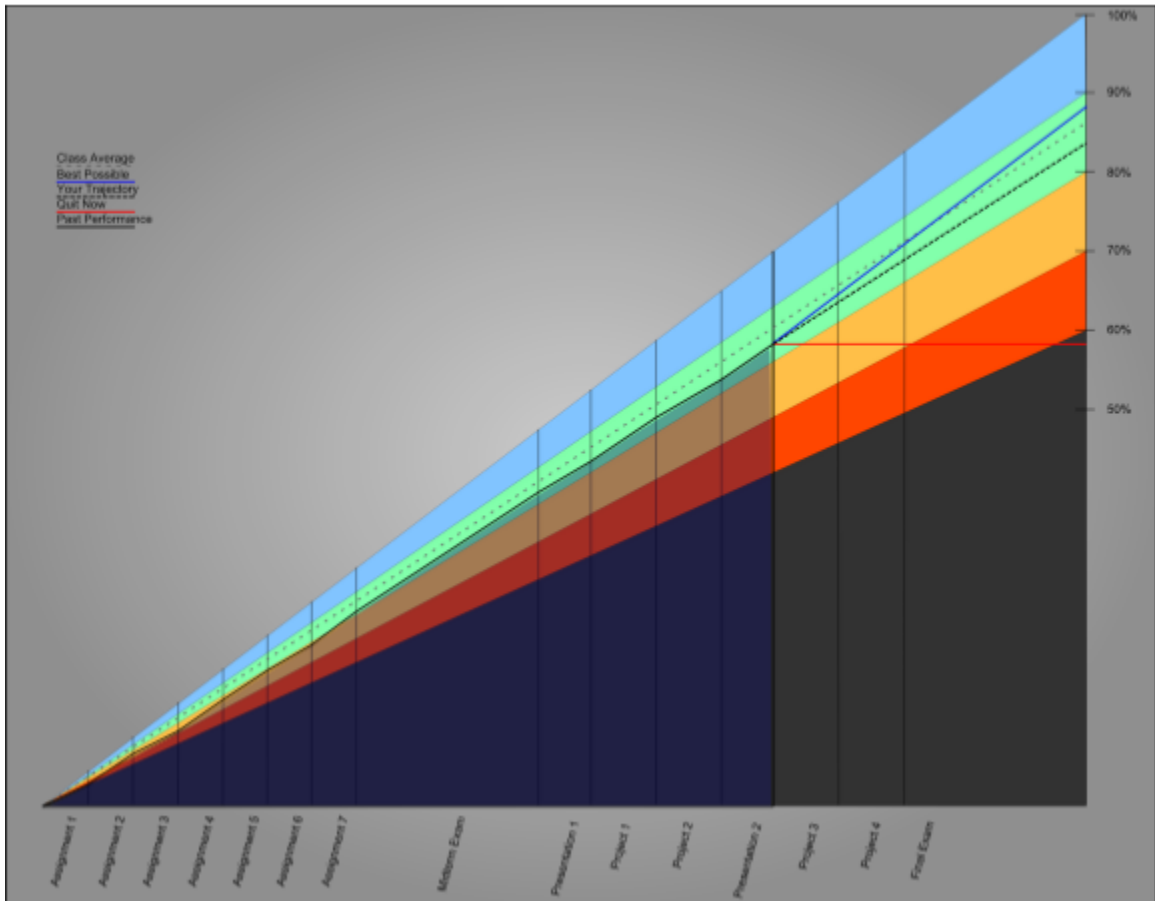


Figure 2.1: Course Burn-Up Chart

The burnup chart will visualize the student's grade showing projections, as well as allow the student to make changes and experiment with possible grades on future assignments. Figure 2.1 and Figure 2.2 show the burn-up chart implementation in Grade-UP Version 1 [4].

The heatmap portion of this project allows the user to view course load over the semester to be better prepared for difficult weeks and plan their semester accordingly. For this graph, the x-axis represents time over an interval, while the y-axis represents the work load during that interval. Students can get an easy understanding of their course load for any period of time throughout the semester

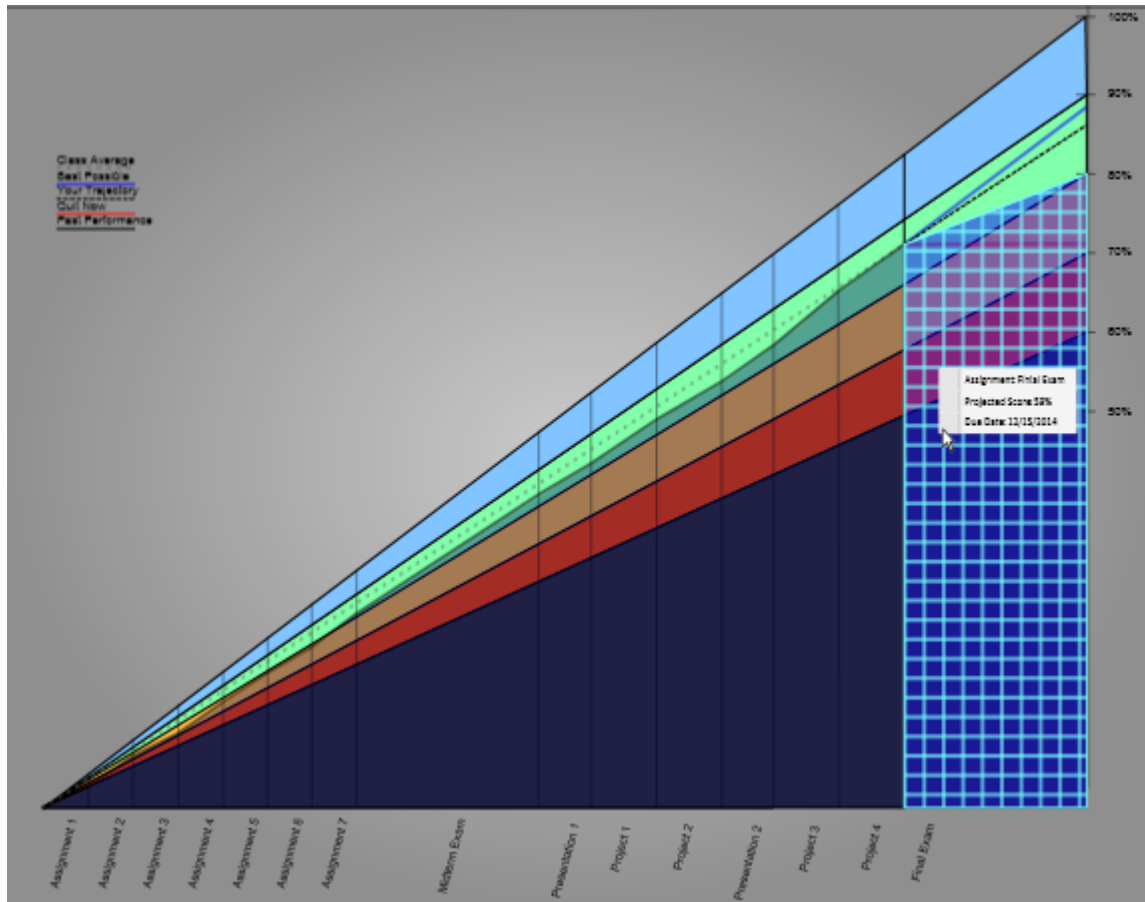


Figure 2.2: Burnup Chart where a student explores the effects of a final exam grade.

at merely a glance. The student can also see assignments that are overdue denoted by a 'warning' icon. Figure 2.3 shows an approximate view of the initial proposed heatmap [4].

Shortly after GradeUp v1.0 was successfully completed, Moodle updated from version 2 to version 3 with significant changes to the plugin structure and rendering Gradup v1.0 obsolete. Currently Moodle is running version 3.9.1 and GradeUp v1.0 is in need of an update to become functional again. To do this, Several changes needed to be made for the next iteration of GradeUp: dependencies needed to be updated, the plugin needed to be integrated with the new version,

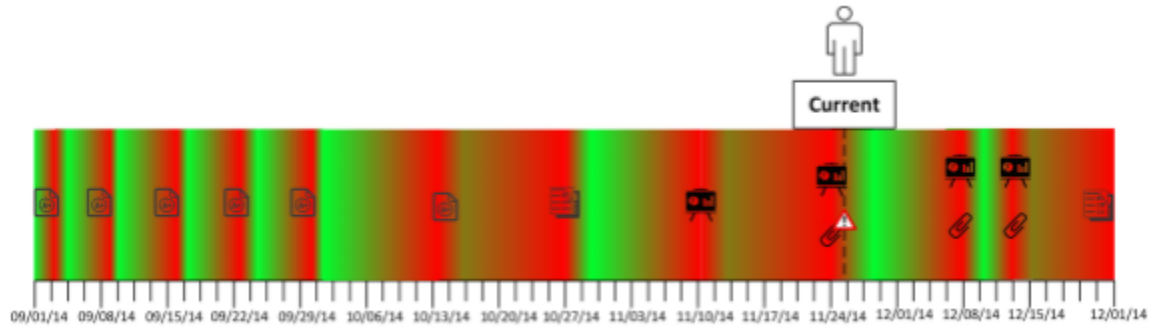


Figure 2.3: The heat-map displays the intensity of work over time.

and documentation needed to be created for users and developers in the future.

Chapter 3

Project Solution/Approach

We proposed to modify the current version of Grade-up so that it would run as originally intended on Moodle version 3.9. We also proposed to standardize the code to match the Moodle community's coding framework [8].

The first project goal was to update the current GradeUp dependencies since most of the original dependencies were out of date. Being out of date, these could result in potential security vulnerabilities, but could also lead to code incompatibilities when interfacing with the Moodle API.

The second project goal was to update the base structure of the plugin to comply with industry standards for Moodle plugins. An initial inquiry from some current Moodle developers revealed a few comments about how GradeUp differs from the standard accepted plugin practices. The first comment was that the Language strings should be in the Lang directory vs their current distribution throughout the source code. The second comment was directed at the existence of a model directory that accesses many other directories. We discovered that these comments were not directly pertinent to our work, or completely relevant, but they did need to be explored to better understand how to match our plugin to the

correct Moodle plugin format [9].

The final project goal was to provide a comprehensive set of documentation files for the plugin as a deliverable. GradeUp v1.0 had no documentation aside from the previous student's proposal and final paper. Our goal was to provide documentation describing the GradeUp software architecture as well as the file system layout. This would make the plugin more easily understandable to any future developers who would like to develop GradeUp v3 should there be a future Moodle update. In addition to software documentation, we proposed to deliver installation and deployment instructions to anyone who would like to use our plugin in the future. This addition of a user guide would also help students and other users to understand how to use GradeUp.

The final deliverables were to be composed of a GitHub repository containing all of the source code as well as the supporting documentation. Finally, we would work with Moodle and submit GradeUp v2 to be added to Moodle's official plugins directory.

3.1 Task Delineation

GradeUp's development was difficult to break down into different parts beforehand but the primary milestones included:

1. Build the Burnup Chart
2. Build the Heatmap Chart
3. Add them to a plugin format for Moodle
4. Pull in grades from moodle and display

Milestone/Major Task	Hours Spent
Gradeup V1 work	36
Data Format Outline	8
Project Design	18
Heatmap Chart V1 using chart.js	12
Burnup Chart Standalone	46
Moodle Installation	35
Gradeup Bluin Exoskeleton	9
Integrating Burnup Chart Into Plugin	11
Pull Student Grades from Moodle	47
Pass Student Grades to burnup chart	16
Heatmap v2 using SVG.js	32
Pass Grades to heatmap	5
Lang Directory Split	3
User Input Options	12
Misc Fixes and Testing	34
Documentation	21
TOTAL	345

Figure 3.1: Major Milestone Delineation

These steps were accompanied by many other steps as the project developed, but are described in detail with approximate working hours for each step in Figure 3.1.

Chapter 4

Testing/Evaluation Plan

To test the functionality and usability of GradeUp v2, we broke our tests down into two different classes: programmatic tests and functionality tests. Programmatic tests use unit testing to find bugs and code errors. Functionality tests include steps for human testers to follow which ensures the project's user interface is acceptable and that the functionality works properly.

For our programmatic testing we used JEST [10]. Jest is a popular JavaScript testing framework that is lightweight and easy to use. We aimed for 100% code coverage of all our calculation functions ensuring that given a specific input, we consistently get the correct output. By using this testing framework, we are able to quickly, effectively, and automatically discover code errors throughout the development life-cycle.

To properly test the GradeUp v2 plugin, we had several users use GradeUp v2 from three different perspectives:

1. Student user
2. Course Instructor

3. Administrator

The student perspective reviews the students ability to answer the following types of questions correctly using the software.

1. What have I completed, and what do I have left to complete?
2. What is my current grade and projected grade at my current pace?
3. Given what I've done so far what is the best possible grade I could get if I ace the remaining work?
4. What if I stopped now, what would my grade be?
5. How am I doing compared to the average in this class?
6. If I got a particular grade(s) on a specific assignment(s) how would that change the answers to the preceding questions?
7. Where is the work left concentrated in the temporal domain?
8. When should I start working on the items left to complete in my course(s)?

The instructor perspective will test to see if the instructor can answer the above questions as well as the following types of question using the software.

1. What is the projected class average?
2. On what assignment did the class perform the worst/best?

Lastly, we tested the installation documentation by asking our testers to follow the instructions for installing and configuring a system with the GradeUp v2 plug-in and received their feedback on the process, as well as the difficulty, and

any problems they faced along the way. After gathering their feedback we used the test results to improve the documentation.

Chapter 5

Results

5.1 User Tests

After an initial analysis a test suite was sent out to six testers who each used the documentation provided to

1. Install a Moodle Dev Environment
2. Install GradeUp onto the Dev Environment
3. Create, configure and populate a course environment for GradeUp to use
4. Complete the functionality tests Survey and Usability Survey based on their experiences

The testers then each sent back the Functionality Tests Survey and the Usability Survey for us to make any changes necessary to either the code or the Documentation. The Usability Survey rated on a scale of 1-5 several questions related to the user Experience such as: "I think that I would like to use this system frequently", and "I felt very confident using the system". This survey is linked below in Appendix

	Average Score
I think that I would like to use this system frequently.	4.7
I found the system unnecessarily complex.	1.3
I thought the system was easy to use.	4.7
I think that I would need the support of a technical person to be able to use this system.	1.0
I found the various functions in this system were well integrated.	4.3
I thought there was too much inconsistency in this system.	1.2
I would imagine that most people would learn to use this system very quickly.	4.7
I found the system very cumbersome to use.	1.3
I felt very confident using the system.	4.8
I needed to learn a lot of things before I could get going with this system.	1.5

Figure 5.1: Cumulative Average Ratings from Usability Survey

B. For each of these feedback questions, if an answer stuck out as marked below a 4/5 (or above a 2/5 for questions where low points corresponded to better ratings), the tester was then asked to provide further feedback or comments as to how the software could be completed. Out of our testers, one user rated the system as difficult to use, though the average overall response was that the system and the documentation was "Excellent" (one mark below "Best Imaginable").

In addition to testing use friendliness, our tests also needed to ensure that the project completed all of its proposed requirements. To accomplish this an acceptance survey was given out to the five students and one faculty member comprising the testing group. This survey is linked below in Appendix B. These test users each used Moodle with GradeUp installed and checked to see if each requirement functionality was present. For these tests we were aiming for a 100% requirement fulfillment, which was met.

5.2 User Comments

In addition to our surveys, we also encouraged users to submit an overall comment with regards to the entire project as a whole. Some of these comments:

1. "I really liked putting the program on the side of Moodle so that it was smaller, out of the way, but where I could always see it."
2. "It Broken"¹
3. "Nice"
4. "I usually find myself trying to calculate what my overall grade would be if I scored a certain percent on an assignment. This would be really practical and convenient if this program was on Moodle for easy use and access. "

5.3 Unit Tests

Our testing framework we used for our automated test was JEST [10]. Since most of the GradeUp functionality was built for visualizing and drawing with SVGs, this portion required manual user tests. However, for the calculation portions of GradeUp we created user tests to ensure that the grades, projections, and averages were all calculated correctly. For the calculation based portions of GradeUp, Jest reported 100% code coverage with all tests passing which was our target goal.

¹It should be noted that this user received a broken version of GradeUp that was fixed before he filled out his surveys

5.4 Evaluation

GradeUp has been completely re-written and tested to now work with Moodle Version 3. Gradeup has also been run on Moodle Version 4 and works properly, though due to version 4 not being fully released yet, we cannot guarantee it will work on the released version. In addition to an updated re-write, GradeUp now uses a more up-to-date SVG - based library for constructing the burnup chart and Heatmap. This is a lightweight library designed to work with zero dependencies. This will ensure GradeUp does not become obsolete due to outdated dependencies, and will aid in long-term sustainability. A screenshot has been included in [Figure 5.2](#). GradeUp has been written to comply with Moodle coding guidelines and has been submitted to Moodle to become an official plugin; however, we have not received any feedback and based on the feedback received by a few plugins further ahead in the queue, we are not expecting official acceptance for at least several weeks [11].

5.5 Unexpected Results

There were not many unexpected results while developing this project. Navigating Moodle's database format was initially a challenge due to Moodle not using foreign keys in the relational database [12]. Documentation was eventually found to overcome this obstacle. Another surprise was the discovery that the teacher's view of GradeUp was not working properly shortly before shipping. This was also solved but was an unwelcome surprise so close to the end of the project. An additional surprise was user feedback from the testers. Almost all of the testers reported more feedback on the documentation for GradeUp than the actual

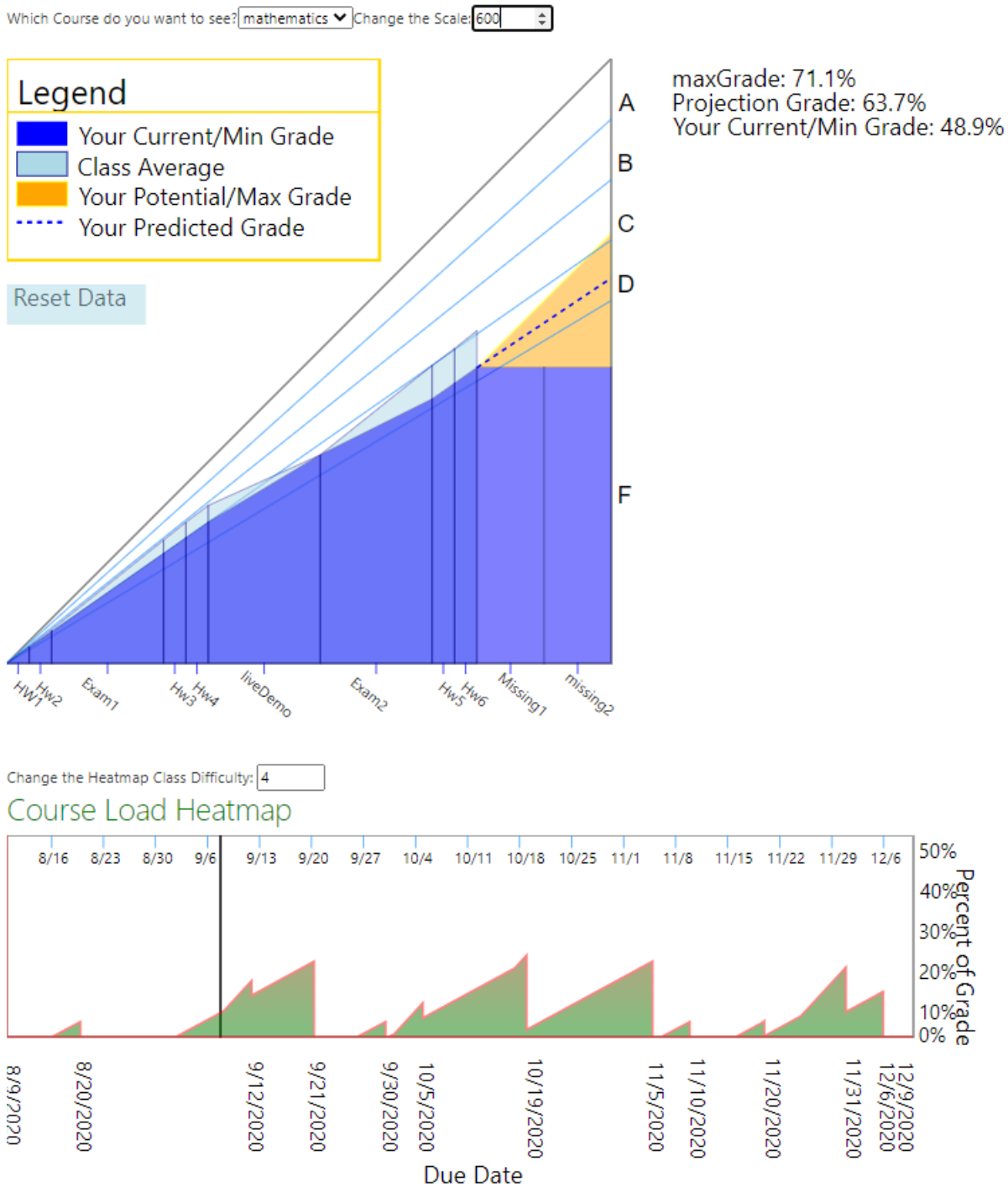


Figure 5.2: Final Burnup and Heatmap Charts

GradeUp Plugin.

Chapter 6

Conclusion

This project had three primary goals:

1. Update GradeUp to work with current Moodle Releases
2. Provide Comprehensive documentation for all GradeUp Users as well as for future developers and administrators
3. Submit the plugin for inclusion into the official Moodle Plugins Directory

We have successfully completed all three of these project goals. GradeUp successfully installs and runs on modern Moodle Versions, and the documentation has been reviewed, tested, and used to ensure that it does provide users with the information they need to use GradeUp. Finally, though GradeUp has been submitted to Moodle for official acceptance, due to Moodle's open-source development, it could take a number of weeks to months to receive a final review [11].

As a final project deliverable, this project is being handed over to the School of Computing at Southern Adventist University. Dr. Anderson has been added to the Moodle Forum as a co-owner (to be owner after defense completion). In addition to the Moodle forum ownership of GradeUp, he will also receive a copy of the

GradeUp source code in its entirety as well as a GitHub fork of the repository containing all necessary files for development and sustainment. GradeUp 2 has been successfully updated to work with version 3 of Moodle, and the code has been officially handed over to School of Computing.

6.1 Future Work

Throughout the course of developing GradeUp 2 we have also accumulated a number of suggestions for future work that could improve it. The heatmap chart could be updated to pull assignment data for all classes the user is currently enrolled in to provide an aggregate view of the student's work load. Create added functions to allow the instructor to view data for individual students in the class. The heatmap could be updated to show which assignments are due on certain dates when the user hovers over them. The scale could be made to auto-resize based on the resolution of the block in Moodle instead of being a user-set field. In addition, the ability to change a course's difficulty as a setting for the heatmap could allow students to select more difficult courses to show as a higher intensity than easier ones. A tester also suggested the ability to show or hide assignment averages for students who may feel demoralized if their performance is below the average.

Appendix A

Documentation Links

Moodle Developer Environment Setup Guide: https://github.com/sypesypher/block_gradeup/blob/master/docs/1%20Moodle%20Developer%20Environment%20Setup%20Guide.md

Moodle Developer GradeUp/block Installation Guide: https://github.com/sypesypher/block_gradeup/blob/master/docs/2%20Install%20Gradeup%20or%20other%20blocks%20into%20your%20Moodle%20Dev%20Environment.md

Moodle Course Environment Setup Guide: https://github.com/sypesypher/block_gradeup/blob/master/docs/3%20Setup%20Moodle%20Course%20Environment.md

Appendix B

Tester Surveys

Gradeup Acceptance Survey

Test	Yes	No	Comments
Does the burnup chart show the student's Current Grade?			
Does the Burnup chart show the Class Average Grade? (if the professor has made the average visible in the gradebook)			
Does the Burnup Chart show the student's minimum possible grade?			
Does the Burnup chart show a projection of what grade the student will possibly get?			
Does the burnup chart show a maximum Possible grade for the student?			
Does the burnup chart Allow the user to enter "what-if" grades?			
Does the burnup chart update to show the student's current grade from the "what if"?			
Does the burnup chart update to show the student's potential grade from the "what if"?			
Does the burnup chart update to show the student's maximum grade from the "what if"?			
Does the burnup chart update to show the student's minimum grade from the "what if"?			
Does the burnup chart have an option to reset your what-if grades?			
Does the reset work?			
Does the burnup chart show grade data when hovering over an assignment?			
Does the heatmap chart have a line showing the current date?			
does the heatmap show the start date and end date of the course?			
Does the heatmap display week markers denoting the end of each week?			
Does the heatmap show the due dates for assignments			
can you change the displayed class difficulty for the heatmap?			
Does changing the difficulty work?			

Based on your experience with Gradeup, rate the following statements. If you are not sure how to respond, mark "3".

	Strongly Disagree			Strongly Agree	
1. I think that I would like to use this system frequently.	1	2	3	4	5
2. I found the system unnecessarily complex.	1	2	3	4	5
3. I thought the system was easy to use.	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system.	1	2	3	4	5
5. I found the various functions in this system were well integrated.	1	2	3	4	5
6. I thought there was too much inconsistency in this system.	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly.	1	2	3	4	5
8. I found the system very cumbersome to use.	1	2	3	4	5
9. I felt very confident using the system.	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system.	1	2	3	4	5

11. Overall, I would rate the user-friendliness of this product as:

Worst Imaginable	Awful	Poor	OK	Good	Excellent	Best Imaginable
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Comments:

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