Improving Introductory Computer Science Courses Through Learning Analytics

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Abstract

The field of technology is a rapidly rising, yet there are few students pursuing the field of computer science. Using learning analytics can provide insight into how students learn and improve the quality of their learning experience. In this paper we discuss the development of a Learning Management System (LMS), collect data on students use of the system, and analyze data to find trends in how they use it.

1. Introduction

The use of technology in society continues to rise and with that the demand for undergraduate students in these fields rise as well. For students to continue with computer science, it is important they have a positive experience in their first programming course. Learning Analytics, an emerging field of research, can be used to gain insight into students taking the course and customize their learning experience to fit their learning needs. Learning analytics is defined as “the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs” (Long and Siemens 34).

Learning Management Systems (LMS) have the ability to collect actions students take on the system, every click, download, assignment upload, etc. There is valuable data available that is often not used by instructors. Instructors, in the past, have relied on hunches in order to know when students are struggling but “learning analytics promises to make these hunches and the resulting action more data-driven and easier to detect” (Dietz-Uhler and Hurn 20). Analyzing learner produced data recorded from a learning management system can tell us a lot about how students learn, understand what topics students struggle with, and what activities are correlated with students’ final marks. Making this data available to instructors in real time would provide instructors valuable feedback with how students are doing in the course and allow them to make adjustments as needed. In addition, if students are able to visualize how they are doing in the course compared to other students they can take action to improve their mark. In order to retrieve this data, a custom learning management system has been developed and piloted by the first year Computer Programming I course at the University of British Columbia Okanagan. This system includes features such as a discussion forum, quizzes, slides, lab/assignment submissions, personalize stats, grades, surveys, and administrative functionality. A custom learning management system allows us to collect data based on use of the system, perform data analysis to predict trends, and display findings back to both students and instructors on a personalized dashboard.

1.1. Previous Research

Although learning analytics is a relatively new field of research, it has become a focus for many institutions and researchers. Learning analytics have been used to create personalized dashboards, find factors that contribute to student success, and predict students at risk of dropping out.

Personalized dashboards help students and instructors visualize valuable information found from the data collected and enhance the interaction between students and instructors (Podgorelec and Kuhar, 2011). Park and Jo (2015) developed an application call LAPA (Learning Analytics for Prediction and Action) to show students their online behavior patterns. The model contains three segments: learning, prediction, and action. Bakharia and Dawson (2011) developed SNAPP to provide instructors with a visualization of relationships in discussion forums. They found that students formed cliques based on academic potential where high performing students tend to flock to other high performing students. Through the analysis Podgorelec and Kuhar's (2011) personalized dashboard, they developed a model that suggests student success depends on the students motivation and average grade. If a student is highly motivated they will pass their exam, if they are not but have a high average grade they are still very likely to pass.

Of the researchers that use learning analytics to find factors that contribute to student success, Macfadyen and Dawson (2010) at UBC Vancouver collected and analyzed student data of an online course from the LMS Blackboard Vista. This study found that the most significant predictor of a student's final grade was the contribution of messages to the course discussion forum and not the total amount of time on the LMS. Morris, Finnegan, and Wu (2005) also found that the number of discussion posts viewed, number of content pages viewed and seconds viewing the discussions where the strongest predictors of final grads. Yu and Jo (2014) found that total studying time in LMS, interaction with peers, regularity of learning interval in LMS, and number of downloads were the strongest predictors in final marks.

To improve retention and help students succeed in courses researchers have used learning analytics to predict at risk students. This helps instructors know when to intervene before students drop out or fail. The University of Purdue has developed Course Signals (CS), a software which uses learner analytics to generate personalized emails that instructors can send students that detail their current performance in the course. The software uses data from the schools Learning Management System, Blackboard Vista, and predicts student's performance based on grades, demographic characteristics, past academic history, and students' effort measured by interaction with the LMS (Arnord and Pistilli, 2012). CS was used to improve retention at the university and it was shown that students who "participated in at least one Course Signals course are retained at rates significantly higher than their peers who had no

Course Signals classes but who started at Purdue during the same semester." (Arnord and Pistilli 268). Another software that has been developed to identify and treat at risk students is the Student Success System (S3). S3 identifies at risk students as well as breaks down student success into five components in order to provide students more meaningful information on areas they may be struggling. The Success Index is composed of the following indices: Preparation, Attendance, Participation, Completion and Social Learning (Essa and Ayad 158).

This paper hopes to further explore these areas of research as well as analyze student's behavioral data collected from surveys and find trends from the class use of the system that would help instructors in real time.

2. Approach

2.1. Problem of Interest

The focus of this project was how can the first year computer science experience be improved? In order to answer this question, several research questions were targeted to provide information instructors could use to optimize how they teach the class. Research questions include:

- What trends can be found in student use of the LMS?
- Which activities are significantly correlated with student achievement?
- How can data collected from the LMS be used to improve future courses?

2.2. Study Population

This research was conducted during the winter term of 2016 (Jan 4 - April 19) on the Computer Programming I course at the University of British Columbia Okanagan. This course had a class size of 69 students, all of whom used the LMS. Of the 69 students that participated in the use of the LMS, 51 were male and 18 were female. There were 40 students pursuing a Bachelor of Science degree, 13 students pursuing a Bachelor of Arts degree, 8 students pursing a Bachelor of Management, 4 students pursuing a Bachelor of Applied Science degree, 1 student pursuing Bachelor of Human Kinetics degree, 1 Visual Arts student, and 2 students with unlisted programs. At the time of the study, 47 of the students were in first year, 12 in second year, 5 in third year, 4 in fourth year and 1 student with an unlisted year.

2.3. Website Development

The LMS that was developed is called Course Canvas. It provides easy to use features, data collection and data analytics. Students have mentioned difficulties in using other LMS such as Blackboard Connect due to slow loading times, cluttered design, and difficult navigation. Course Canvas provides a minimalistic design, with easy to use features, and maintains quick page loading times. The website was developed using HTML, Sass, PHP and uses a MySQL database. Laravel was used as the PHP framework and Bootstrap for front end framework. Third party libraries used include Swipebox, a jQuery plugin used to create a lightbox when slides are expanded and Intervention Image, to create thumbnails of slides.

2.4. Data Collection

Data was collected for one full term (Jan 4 – April 19) on the use of the website both through Google Analytics and in the database. During analysis of the data, Google Analytics was found to have slightly skewed some of the data. Specifically, the amount of time on a page is only collected if a user continues on to another page before ending their session. This is due to Google analytics calculating the time on a page with the time leaving the site minus the time entering the site. Thus the time tracked may be less than expected if a student spends a large amount of time on a page and exits before the data is logged. All variables collected are displayed in the appendix. Table 7 lists the variables collected from the LMS and Table 8 lists variables collected from Google Analytics.

3. Website Features and Data Collection

3.1 User Authentication

Students must sign up to the website to view all pages outside of the home page. This allows the data collected to be associated with the unique user signed in.

3.2 Discussion Forum

A discussion forum (Fig. 1) was implemented to allow students access to the instructor outside of lecture and lab times as well as a platform to communicate with classmates who may face similar problems. Unique features of this discussion forum include anonymous thread posts and filtering post by category. The user interface is easy to use and sorted by the latest post.

The discussion forum collects number of questions posted, replies posted, category of post and total amount of time spent on the forum is tracked for each user.

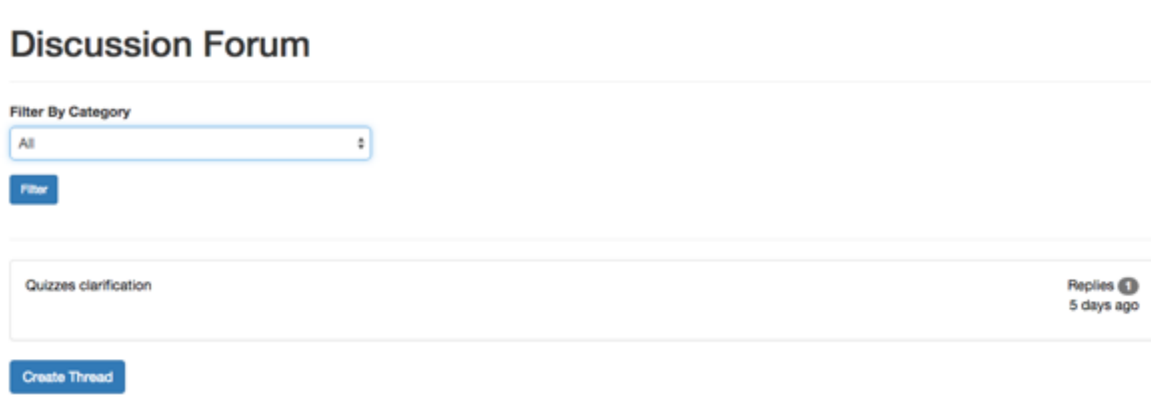


Fig. 1. Discussion Forum

3.3. Slides

An easy to use slides system was implemented to allow students access to slides that are presented during lecture. Slides (Fig. 2), which are organized by topic, are displayed as thumbnails to allow students to find the information they are looking for quickly. Once the thumbnail is clicked the slide expands to full size with a lightbox background to optimize student focus. Students can then navigate left and right for smooth transition of slides. Displaying slides as images allows data to be collected on the amount of time each user spends on a topic.

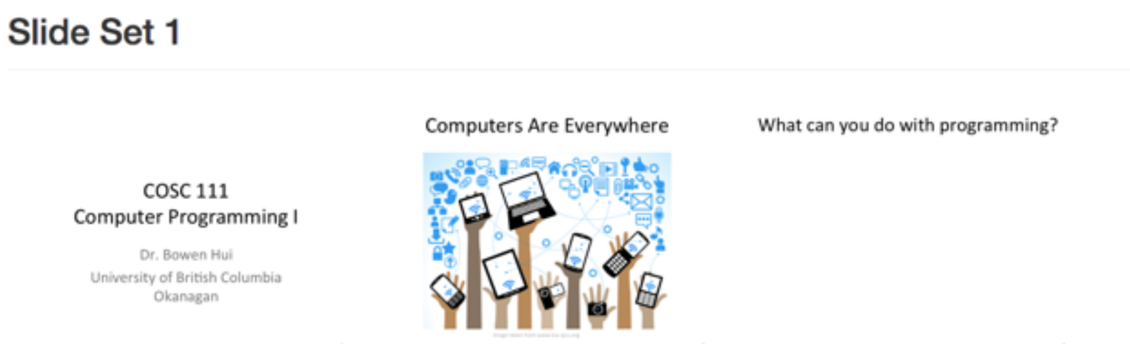


Fig. 2. Slides Set 1

3.4. Submissions

Labs and assignments are submitted online by attaching files and adding any additional comments (Fig. 3). The submission is associated to the specific student and is stored in the database for instructors to mark. The time of the submission and the number of attempts are tracked for each user.

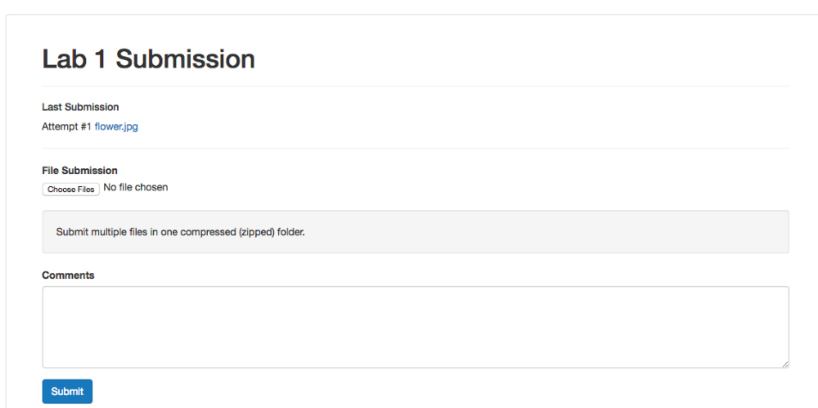


Fig. 3. Lab 1 Submission

3.5. Quizzes

Quizzes (Fig. 4) can be taken by students for marks. This allows students to practice concepts taught in class and lab. Their quiz score and attempt number is track for each user when a quiz is taken. Unique features include allowing users to retake quizzes after 24 hrs and shuffling questions and answers each time it's taken.

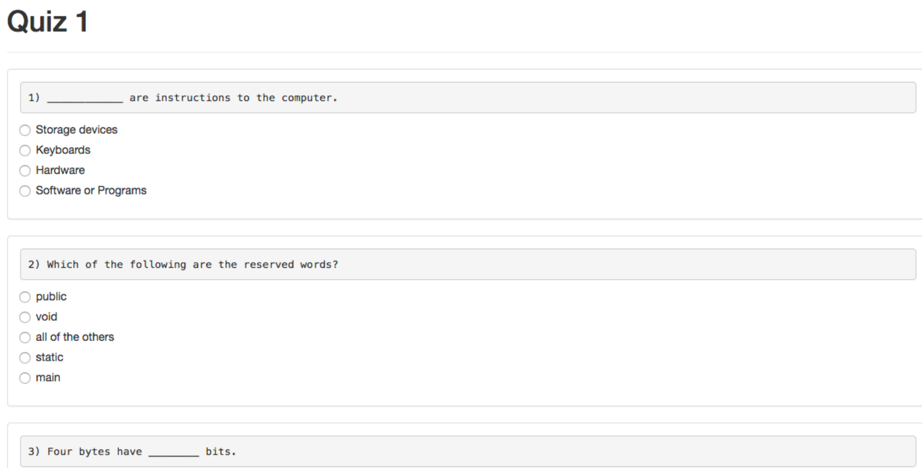


Fig. 4. Quiz 1

3.6. Marking

Users who have been given admin status have the ability to mark submissions. This allows instructors to view and grade student submissions, add grades for activities that do not require submission, or edit existing grades. The user interface for adding and editing grades is shown in Fig. 5.

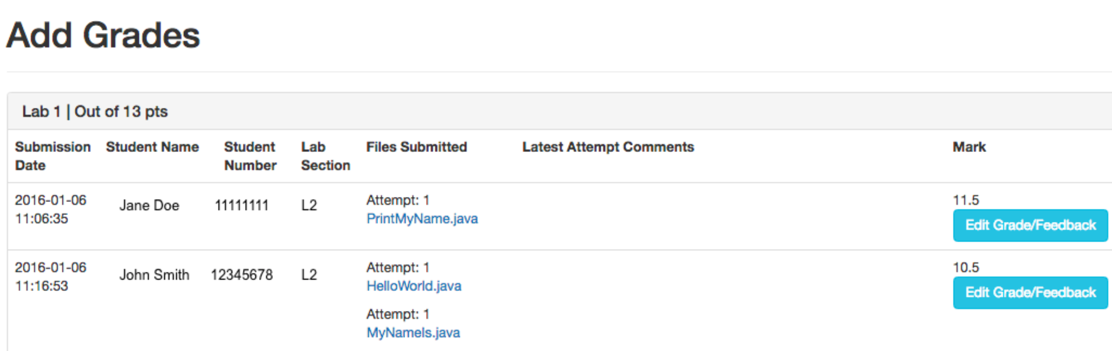
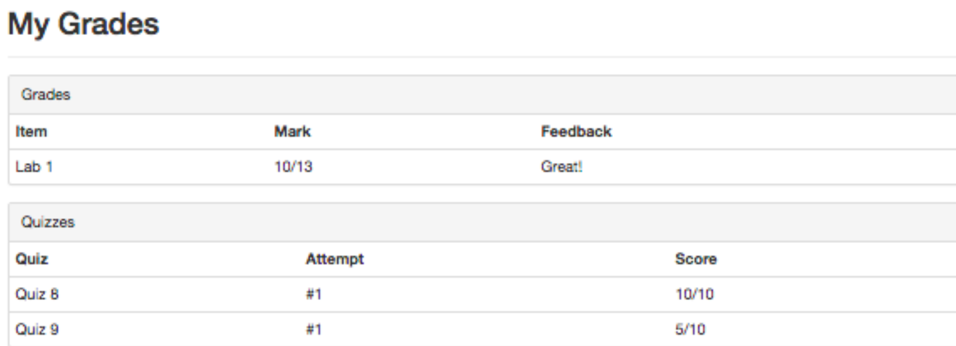


Fig. 5. Lab 1 Marking

3.7. Grades

Students have the ability to view the marks they receive from instructors (Fig. 6) as well as keep track of marks received from taking online quizzes.



My Grades

Grades

Item	Mark	Feedback
Lab 1	10/13	Great!

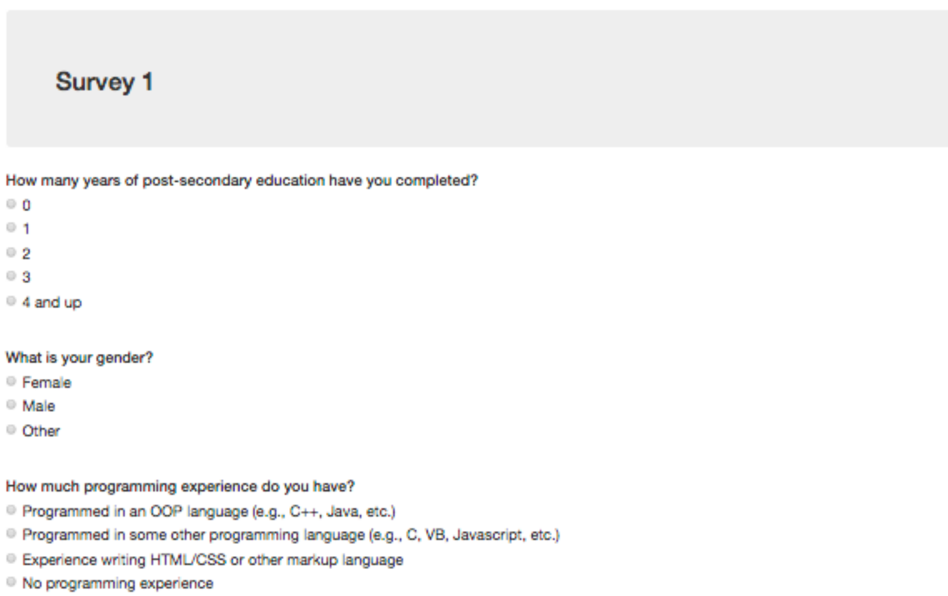
Quizzes

Quiz	Attempt	Score
Quiz 8	#1	10/10
Quiz 9	#1	5/10

Fig. 6. An example page for student grades

3.8. Surveys

Surveys (Fig. 7) were created on the site to collect information on behavioral attributes of the students. Three surveys were implemented in this class, the first one collected background information on students in the course and the second and third surveys were to collect information on student study habits from midterm 1 and midterm 2 respectively.



Survey 1

How many years of post-secondary education have you completed?

- 0
- 1
- 2
- 3
- 4 and up

What is your gender?

- Female
- Male
- Other

How much programming experience do you have?

- Programmed in an OOP language (e.g., C++, Java, etc.)
- Programmed in some other programming language (e.g., C, VB, Javascript, etc.)
- Experience writing HTML/CSS or other markup language
- No programming experience

Fig. 7. Survey 1

3.9. Statistics

Statistics of assignments averages are available to view to both students and instructors. Student stats display a personalized chart (Fig. 8) displaying their marks against the class average. This will allow students to visualize their marks and progress in the course. Instructors stats include the class averages for each assignment as well as trends in student use of the site. Details can be found in Results (pg. 7).

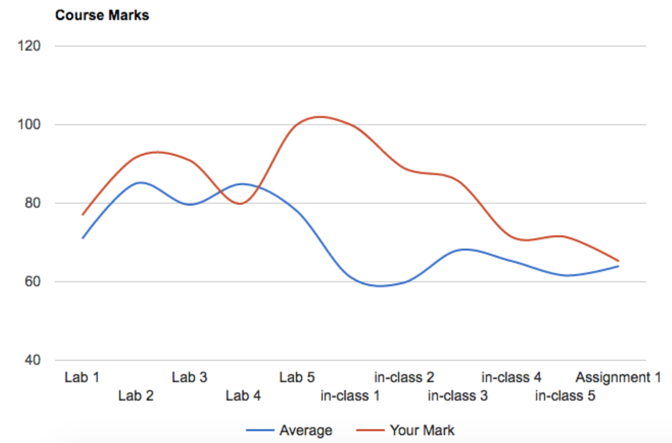


Fig. 8. Example of student stats

4. Results

4.1 Surveys

Three surveys were given to students throughout the year on the LMS, all surveys were optional. Survey 1 was available to be taken at the start of the semester, Survey 2 was available after the first midterm and Survey 3 was available after the second midterm. Survey 2 and 3 contained the same questions in order to help us find which variables were the strongest behavioral predictors of each midterm. Results of Survey 1 shown in Table 1 and results of Survey 2 and Survey 3 are shown in Table 2.

Table 1. Survey 1, N (number of participants) = 50.

Question	Responses N = 50
1. How many years of post-secondary education have you completed?	
0	46%
1	22%
2	6%
3	20%
4 and up	6%
2. What is your gender?	
Female	36%
Male	64%
Other	0%
3. How much programming experience do you have?	‘
Programmed in an OOP language(e.g. C++, Java, etc.)	8%
Programmed in some other programming language (e.g. C, VB, Javascript, etc)	10%
Experience writing HTML/CSS or other markup language	10%
No programming experience	72%

4. Why are you taking this course?	
I intend on majoring in computer science	14%
I am exploring the possibility of majoring in computer science	36%
I need it for a non-computer science degree requirement	24%
This course seems like an easy elective	6%
Other	20%
5. What mark did you get in the prerequisite math course (one of PREC 12, MATH 12, MATH 125)?	
90% or above	32%
80%-89%	48%
70%-79%	18%
less than 70%	4%
I have not taken any of the prerequisite math courses	2%
6. What mark do you plan to get in the course?	
90% or above	24%
80%-89%	48%
70%-79%	22%
60% - 69%	0%
50%-59%	0%
No plans, I'm just going to do the best I can	6%
7. How much time do you plan on spending on this course outside class/lab time each week?	
Less than 1 hour	4%
1-2 hrs	22%
3-4 hrs	44%
4-6 hrs	22%
6-8 hrs	6%
8+ hrs	2%
8. Indicate to what extent do you agree with the following statement: "You are good at taking tests."	
Strongly Agree	4%
Agree	18%
Neutral	58%
Disagree	16%
Strongly Disagree	4%
9. Indicate to what extent do you agree with the following statement: "You do all the assigned homework and readings to the best of your ability."	
Strongly Agree	18%
Agree	60%
Neutral	16%
Disagree	4%
Strongly Disagree	2%

10. Indicate to what extent do you agree with the following statement: “You understand what you read in textbooks.”	
Strongly Agree	8%
Agree	62%
Neutral	20%
Disagree	6%
Strongly Disagree	4%
11. Indicate to what extent do you agree with the following statement: “You ask and answer questions in class.”	
Strongly Agree	4%
Agree	30%
Neutral	38%
Disagree	22%
Strongly Disagree	6%

Table 2. Survey 2 and Survey 3 (N represents the number of students that participated in each survey)

Questions	Survey 1 Results N=54	Survey 2 Results N=33
1. Roughly, the number of hours that I spent studying for this midterm was:		
< 2 hours	17%	12%
2-4 hours	33%	30%
4-6 hours	22%	33%
6-8 hours	20%	24%
> 8 hours	7%	0%
2. As part of my test preparation for this midterm, I :		
Read the lecture slides.	41%	45%
Read and worked through the examples in the lecture slides.	54%	52%
Didn’t look at the lecture slides.	6%	3%
3. As part of my test preparation for this midterm, I :		
Reviewed labs and assignments.	44%	64%
Attempted some exercises in the labs and assignments again.	37%	18%
Didn’t study from labs/assignments at all.	19%	18%
4. As part of my test preparation for this midterm, I :		
Read the quiz questions (without doing them).	19%	3%
Practiced doing the quizzes online.	56%	67%
Chose not to study using the quizzes.	26%	30%
5. Using the course textbook, I:		

Read on all the topics on the course schedule to supplement my learning in lecture.	46%	33%
Read some topics on the course schedule to supplement my learning in lecture.	35%	52%
Didn't read my text at all.	19%	15%
6. Using the course textbook, I:		
Worked on all checkpoint questions within each chapter.	9%	12%
Worked on some checkpoint questions within each chapter.	56%	55%
Didn't complete checkpoint questions in the text at all.	35%	33%
7. Using the course textbook, I:		
Worked on some programming exercises at the end of each chapter and checked against solutions provided online.	26%	30%
Worked on and completed some programming exercises but didn't check answers.	28%	39%
Tried some programming questions but was unable to complete them.	13%	9%
Didn't work on programming exercises at all.	33%	21%
8. When I practice doing programming exercises, I:		
Start by understanding the problem, break down the problem into manageable steps, then translate them into Java code.	52%	39%
Start typing Java code into Eclipse immediately.	31%	36%
Start writing Java code on paper and then transfer the finished code into Eclipse.	7%	15%
Didn't do any programming practice.	9%	9%
9. The night before the midterm I managed to get:		
less than 4 hours of sleep.	15%	3%
4-6 hours of sleep.	20%	30%
6-8 hours of sleep.	50%	36%
> 8 hours of sleep.	15%	30%

For each survey, a multiple regression was run to find if there were any relationship between the questions and the students mark. For Survey 1, the independent variables were the questions and the dependent variable was the students overall final mark. There were no significant predictors ($p < 0.05$). The largest predictors of Survey 1 were Question 5 ($p = 0.12$) regarding their prerequisite math 12 mark, Question 8 ($p = 0.12$) being good at taking tests, and Question 11 ($p = 0.18$) asking and answering questions in class.

A multiple regression was also run for Survey 2 and Survey 3 with the independent variables being the questions and dependent variable being the Midterm 1 mark and Midterm 2 mark respectively. Regression results of Survey 2 are shown in Table 3 and regression results of Survey 3 in Table 4.

Table 3. Regression results of Survey 2 using Midterm 1 Mark as dependent variable.

Variables	**p**
Question 1	0.465
Question 2	0.174
Question 3	0.332
Question 4	0.333
Question 5	0.413
Question 6	0.670
Question 7	0.300
Question 8	0.682
Question 9	0.016

Multiple r = 0.45, r^2 = 0.20, Adjusted r^2 = 0.03.

Table 4 Regression results of Survey 3 using Midterm 2 Mark as dependent variable.

Variables	**p**
Question 1	0.063
Question 2	0.753
Question 3	0.882
Question 4	0.983
Question 5	0.665
Question 6	0.325
Question 7	0.728
Question 8	0.615
Question 9	0.613

Multiple r = 0.51, r^2 = 0.26, Adjusted r^2 = -0.03.

The regression of Survey 2 only yielded one significant variable Question 9 (p = 0.016) regarding the amount of sleep gotten the night before. Survey 3 yielded no significant variables but the most significant was Question 1 (p=0.063) regarding the number of hours spent studying for the Midterm 2. This could be because due to the fact that Midterm 2 covers a much larger range of topics and requires students to answer more challenging coding questions resulting in hours spent studying being a stronger predictor to the midterm 2 mark than sleep.

4.2. Trends in Web Use

Data collected from Google Analytics and the database were analyzed to find trends of the student use of the website. Reports are created in Google Sheets to pull in data from Google Analytics, reports are run every hour to display the most up to data information to instructors. Charts are created by querying the data pulled from the reports and embedded into the website. Charts are interactive on the website, allowing users to hover over charts to display data points.

Fig. 9. displays the time spent on the site on average for each student on each day. The most time is spent on Monday, the date the lecture occurred this semester. Wednesday, the second highest day, two labs are run and Friday one lab is run.

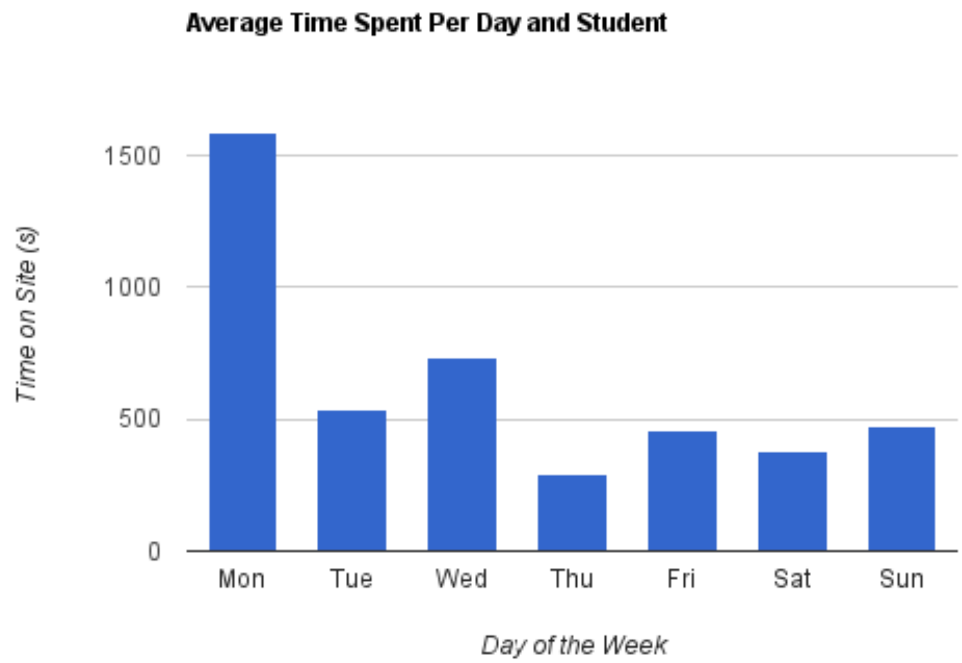


Fig. 9. Chart displays the average time student spends on each day.

Top pages in terms of time spent in seconds per student over the course of the semester are displayed on the dashboard. The chart was split in two charts to make it easier to interpret, Fig 10 contains pages student spend a larger amount of time on and Fig 11 contains the pages with less time spent on. The top pages students visited during this study includes labs, quizzes, homepage, and the thread also know as the Discussion Forum. The lowest pages include stats (which was not deployed until the end of the semester), one of the several individual practice questions slides, and slides for upper level courses and projects. The top page is just under 10,000 seconds, which is approximately 2.8 hours per student. This number may be slightly lower than expected due to the fact that google analytics does not record time spent on an exit page as mentioned above. Although the time logged may be less than expected, the graphs below give instructors a general indication of what topics students find most difficult and where they are investing their time while studying.

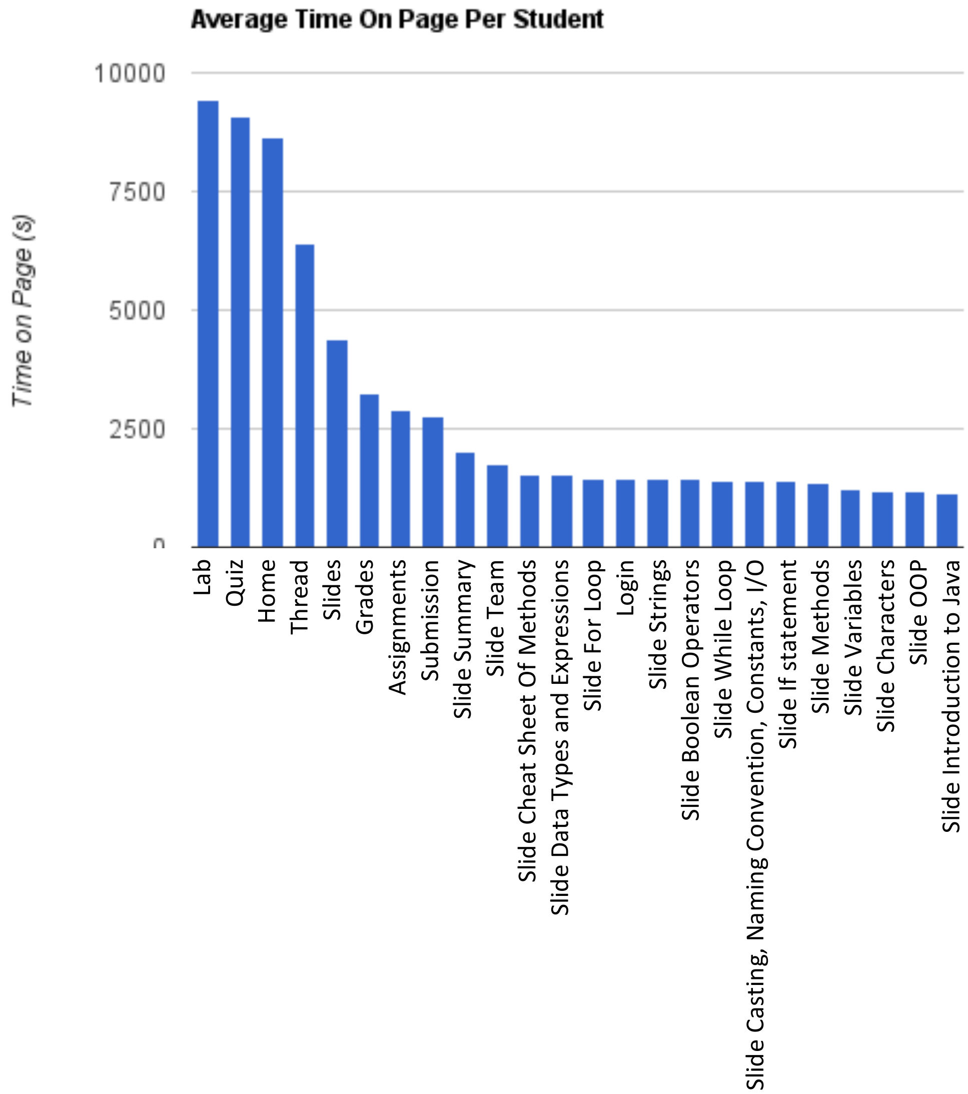


Fig. 10. Chart displays the average time spent on each page per student.

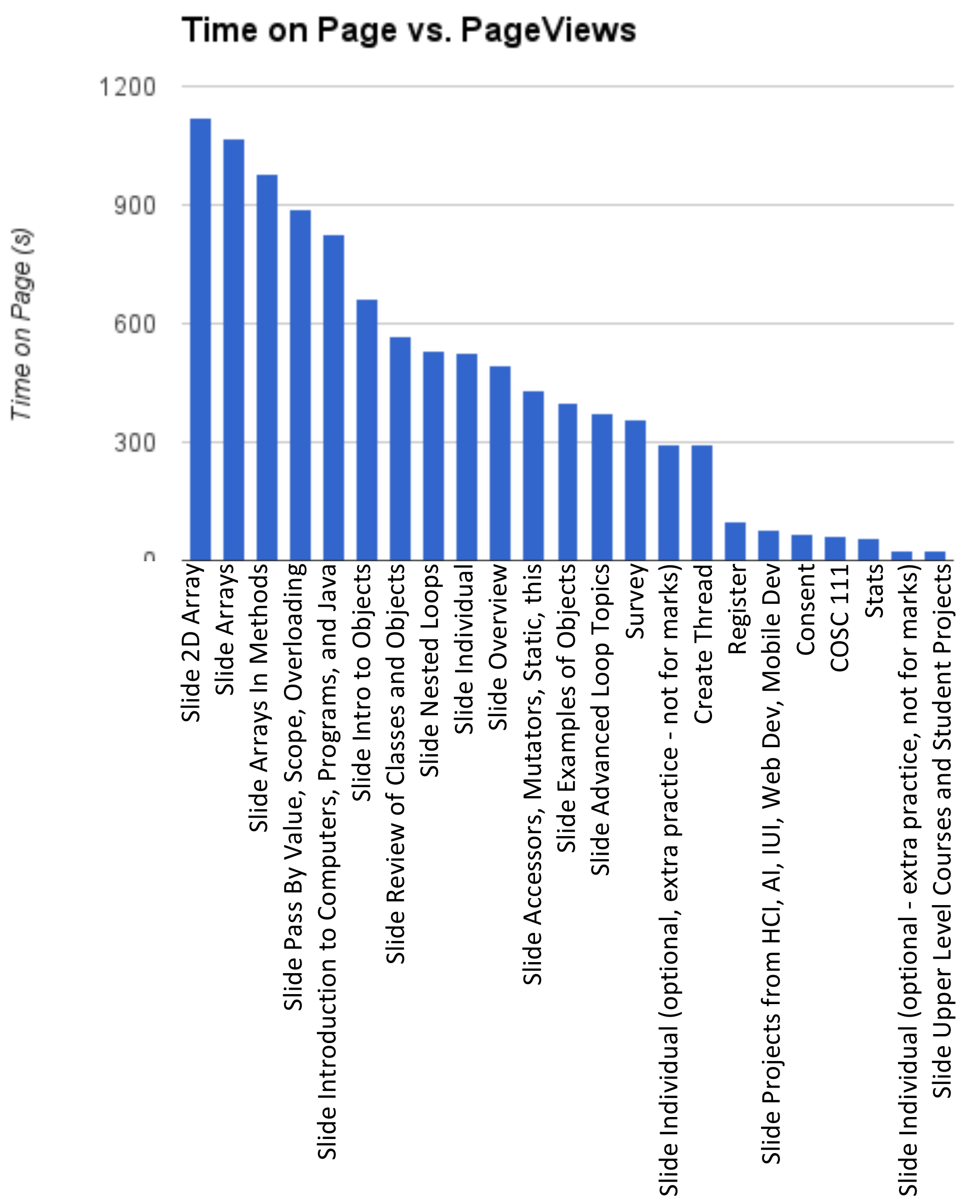
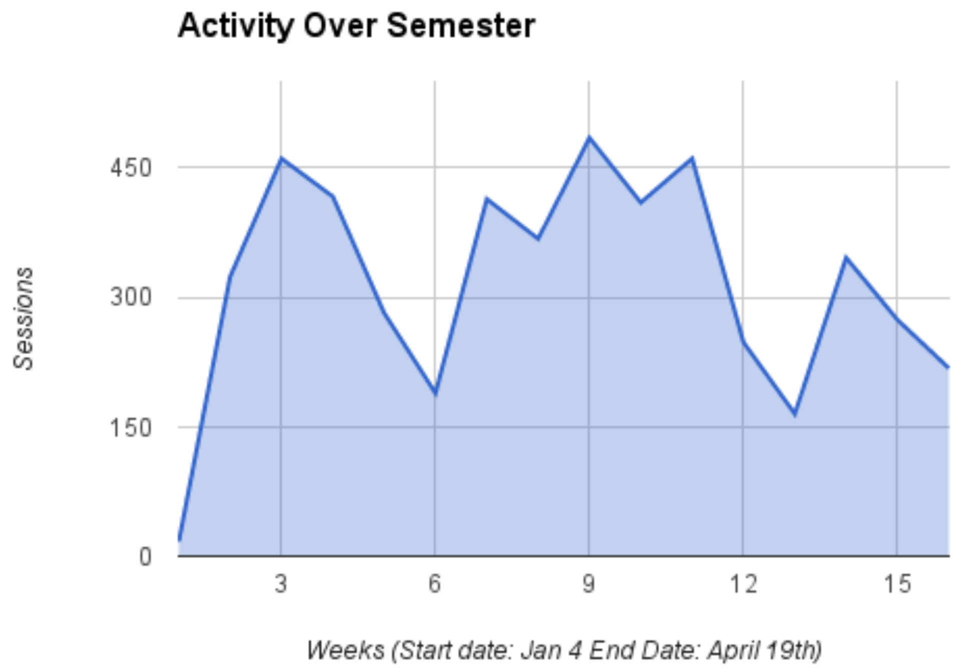


Fig. 11. Chart displays the average time in seconds spent on each page per student.

The website activity on the site over the semester in weeks is shown in Fig. 12. The chart is calculated in total amount of sessions for that week. The chart shows that the site hits peak online sessions when the assignment and midterms occur and lows during reading break and Easter break.



Classes Start - 1
2
Assignment 1 Due - 3
4
5
Reading Week- 6
Midterm 1 - 7
8
Assignment 2 - 9
10
Midterm 2 - 11
12
Easter Break - 13
Assignment 3 - 14
Finals Week (No classes or labs) - 15
Final - 16

Fig. 12. Chart displays the use of the site each week.

Fig 13. displays on the instructor dashboard the top 10 pages that each student is spending time on in the past 7 days. This allows the instructors to see if students are investing their time in the right places. During the week the chart was generated, quizzes due date was approaching so we see a spike in the time spent on quizzes compared to other pages.

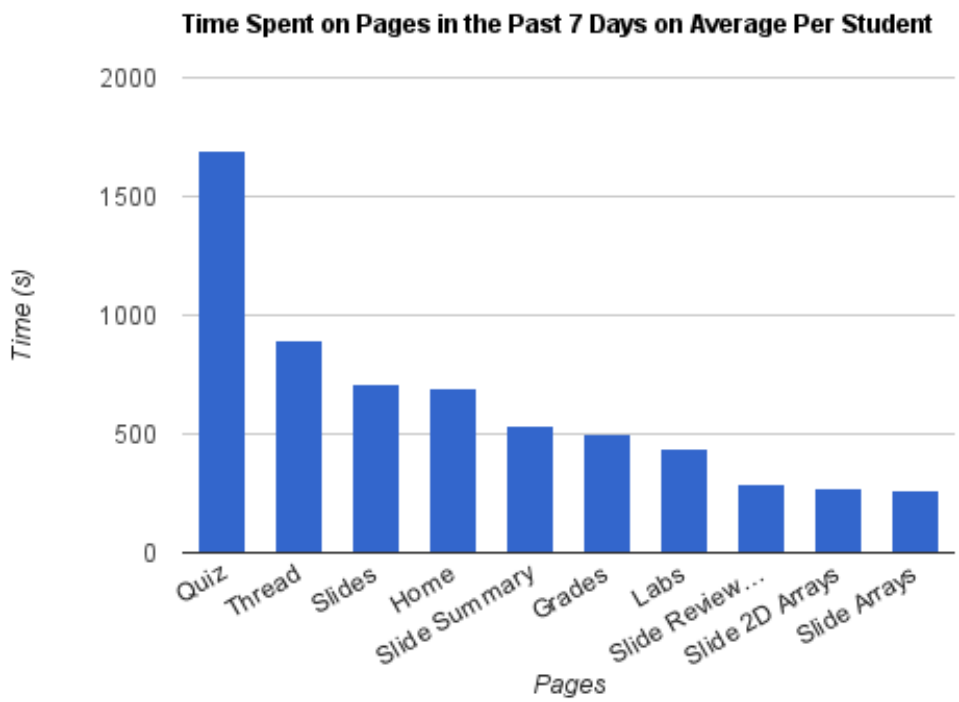


Fig. 13. Chart displays Top 10 pages of the week.

When instructors are interested on the current use of the site, Fig. 14 displays on the instructor dashboard the average number of sessions for each day of the current week against the use of the site on the previous week that each student is spending time on. The maximum amount of time students spend on the site is shown as well so the instructor is able to see how the current week compares to past weeks. This allows the instructors to see a more detailed, day to day version of Fig. 12

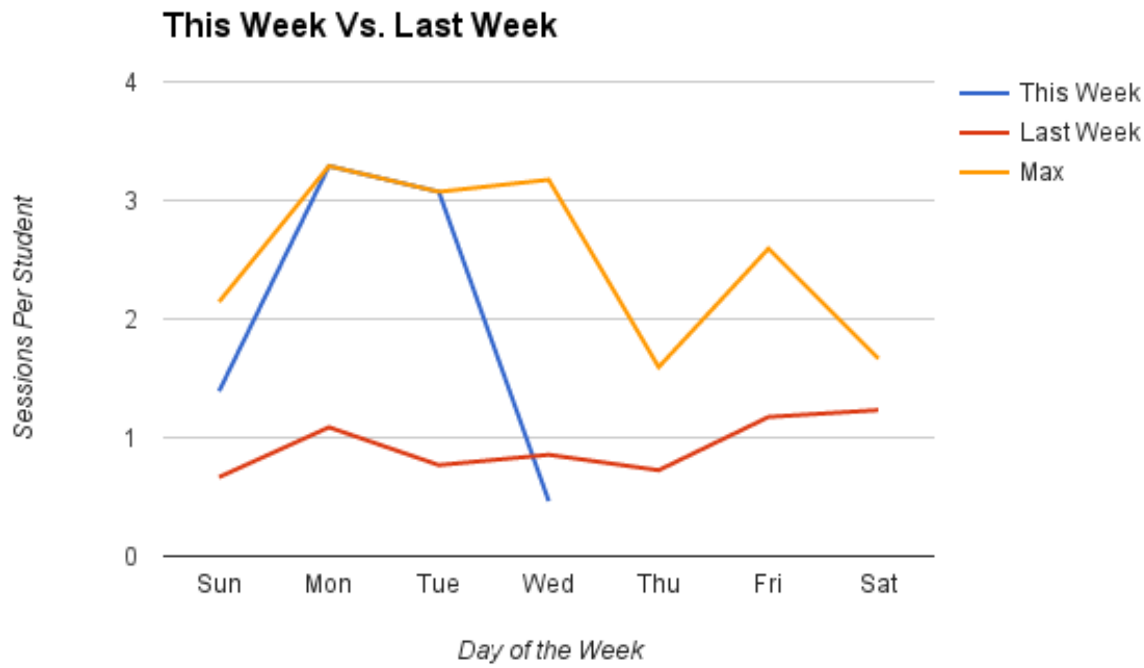


Fig. 13. Chart displays site use of the current week vs the previous week.

4.3. Multiple Regression Analysis

A regression analysis was run after the completion of the course to find which activities are most significantly correlated with student achievement. Independent variables displayed on the left of Table 5 where run against the final mark as the dependent variable.

Table 5. Regression results using Overall Final Mark as dependent variable

Variables	**p**
Labs Avg.	2.43 E-07
Assignments Avg.	0.001
Quizzes Avg.	0.172
In-class Avg.	0.245
Discussion Forum Posts	0.957
Replies Posted	0.648
Midterm 1 Mark	0.042
Midterm 2 Mark	0.692
Online Sessions	0.992
Final Exam Mark	2.53 E-22

Adjusted $r^2 = 0.98$.

Variables that were the highest predictors for the final mark were the final exam mark, lab average, assignment average, and midterm 1 mark.

A multiple regression was then run with the same variables but instead using the Final Exam mark as the dependent variable. As you can see in Table 6 this analysis yielded different results. Midterm 2 and Midterm 1 were the strongest predictor in the final exam mark. This may be a result of the class grading scheme as those who scored better on the final could have their midterm marks replaced and lab/assignment marks may have brought up their mark up as well. The final exam mark represents more of the students understanding in the course and we see that the midterms as well as in-class activities are the strongest predictor of it. The discussion forum and the number of replies may have been less than expect due to usability issues. The site was deployed in early stages of development and lacked more complex features on the forums such as notifications, and tracking read/unread messages which could of lead to less use of the forum.

Table 6. Regression results using Final Exam Mark as dependent variable

Variables	**p**
Labs Avg.	0.262
Assignments Avg.	0.133
Quizzes Avg.	0.715
In-class Avg.	0.012
Discussion Forum Posts	0.223
Replies Posted	0.617
Midterm 1 Mark	7.14X10-4
Midterm 2 Mark	3.79X10-9
Online Sessions	0.164

Adjusted $r^2 = 0.81$.

4.4. Using Data to Improve Courses

Trends found from the students use of the site are displayed in nearly real-time to the instructor on a dashboard. This information can be used to make adjustments in the course that maximizes student learning. For example, knowing students are visiting the site most during the day of the lecture (Fig. 9), posting slides, announcements, and practice questions the day before will allow students to see these before or during lecture. In Fig. 10, Fig. 11 and Fig. 13, the instructor can see what topics students are spending their most time on, and focus on these topics in lecture. The instructor may also guide students in the right direction if he/she notices that students are investing in a topic that is not as important. Exams could be scheduled during times when students are more active on the website shown in Fig. 12. Students are more active on the site before the reading break and Easter break, during the breaks activity greatly decreases. Instructors may be interested to see if use of the site is as expected and when most students are using it. When Fig. 13 was generated, there was an exam occurring on Tuesday, therefore we see the large spike in online sessions on Monday. If the instructor notices the activity is slow or not as expected before a deadline or test, the instructor can post reminders or suggest new ways students can prepare to encourage studying.

From the the multiple regression analysis we found although labs and assignments were a strong predictor in how well students did in the course overall, the in-class assignment marks and midterms were the strongest predictors of Final Exam marks. This may suggest that students who come to class and do in class activities and do well in midterms are more successful in the final exam. Those who do well overall may have done well on labs and assignments, which brings up their overall mark, as long as they passed the final.

5. Conclusion

5.1. Summary

Learning Analytics is a quickly growing area of research as “new approaches are emerging that allow educators to evaluate the learning impact of designed activities in terms of measures of learner community, interaction and engagement” (Macfayen and Dawson 590). Instructors and students “need a foundation on which to enact change” (Long and Siemens 40), and learning analytics helps them do so by aiding in data driven decisions. Collecting and analyzing learner data can provide us with valuable insight to how students learn and how we can better their experience.

A LMS, Course Canvas was developed to collect data from the use of the system, analyse data, and displays information back to instructors and students. Course Canvas was used in the winter term of 2016 on 69 students at the University of British Columbia Okanagan. Behavioural data, collected from surveys, was analyzed and common trends that could be used to improve the course were evaluated and embedded into an instructor dashboard on the website.

5.2 Future Plans

We have been continuing development on Course Canvas. Future plans include piloting the site in more classes to increase the data set, increasing administration functionality, signaling students at risk of failing to instructors, providing personalized suggestions to students for how they can improve in the course, and testing usability of the site.

Appendix

Table 7. Variables collected from the Learning Management System

Variables from LMS
User id
Discussion Forum
Replies
Lab Section
Lab 1 - 9 Mark (Variable for each Lab)
Lab 1 - 9 hrs submitted before due date

(Variable for each Lab)
Assignment 1 - 3 Mark (Variable for each Assignment)
Assignment 1 - 3 hrs submitted before due date (Variable for each Assignment)
In-class 1- 9 mark (Variable for each In-class mark)
Midterm 1
Midterm 2
Quiz 1 - 9 average (Variable for each Quiz)
Quiz 1 - 9 attempts (Variable for each Quiz)
Top Quiz Mark 1 - 9 (Variable for each Quiz)
Data Consent

Table 8. Variables collected from Google Analytics

Variables from GA
Time spent on Slide Boolean Operators in seconds
Time spent on Quiz in seconds
Time spend on Home in seconds
Time spent on Slides Index in seconds
Time spent on Slide Arrays In Methods in seconds
Time spent on Slide Data Types and Expressions in seconds
Time spent on Slide Strings in seconds
Time spent on Slide OOP in seconds
Time spent on Slide For Loop in seconds
Time spent on Submission in seconds
Time spent on Slide Individual in seconds
Time spent on Slide Intro to Objects in seconds
Time spent on Slide Individual (optional extra practice - not for marks) in seconds
Time spent on Slide Introduction to Java in seconds
Time spent on Slide Introduction to Computers Programs and Java in seconds
Time spent on Slide Overview in seconds
Time spent on Slide Cheat Sheet Of Methods in seconds
Time spent on Slide Arrays in seconds
Time spent on Slide Team in seconds
Time spent on Slide Nested Loops in seconds
Time spent on Slide Methods in seconds
Time spent on Slide Summary in seconds
Time spent on Slide Advanced Loop Topics in seconds
Time spent on Slide Projects from HCI, AI, IUI, Web Dev in seconds
Time spent on Slide 2D Arrays in seconds
Time spent on Slide Characters in seconds
Time spent on Slide Examples of Objects in seconds
Time spent on Slide Individual (optional - extra practice, not for marks) in seconds
Time spent on Slide Upper Level Courses and Student Projects, Slide While Loop in seconds

Time spent on Slide Variables in seconds
Time spent on Slide Pass By Value, Scope, Overloading in seconds
Time spent on Slide Casting, Naming Convention, Constants, I/O, in seconds
Time spent on Thread in seconds
Time spent on Create Thread in seconds
Time spent on Labs in seconds
Time spent on Survey in seconds
Time spent on Consent in seconds
Time spent on Grades in seconds

References

Arnold, Kimberly E., and Matthew D. Pistilli. "Course signals at Purdue: using learning analytics to increase student success." *Proceedings of the 2nd international conference on learning analytics and knowledge*. ACM (2012): 267-270.

Bakharia, Aneesha, and Shane Dawson. "SNAPP: a bird's-eye view of temporal participant interaction." *Proceedings of the 1st international conference on learning analytics and knowledge*. ACM, 2011.

Dietz-Uhler, Beth, and Janet E. Hurn. "Using Learning Analytics to Predict (and Improve) Student Success: A Faculty Perspective." *Journal of Interactive Online Learning* 12.1 (2013): 17-26. Web.

Essa, Alfred, and Hanan Ayad. "Student success system: risk analytics and data visualization using ensembles of predictive models." *Proceedings of the 2nd international conference on learning analytics and knowledge*. ACM (2012): 158-161.

Long, Phil, and George Siemens. "Penetrating the Fog: Analytics in Learning and Education." *EDUCAUSE Review* (2011): 31+. Web.

Macfadyen, Leah P., and Shane Dawson. "Mining LMS Data to Develop an ‘‘Early Warning System” for Educators: A Proof of Concept." *Computers & Education* 54 (2010): 588-599. Web.

Morris, Libby V., Catherine Finnegan, and Sz-Shyan Wu. "Tracking student behavior, persistence, and achievement in online courses." *The Internet and Higher Education* 8.3 (2005): 221-231.

Park, Yeonjeong, and Il-Hyun Jo. "Development of the Learning Analytics Dashboard to Support Students' Learning Performance." *J. UCS* 21.1 (2015): 110-133.

Podgorelec, V., and S. Kuhar. "Taking advantage of education data: Advanced data analysis and reporting in virtual learning environments." *Elektronika ir Elektrotechnika* 114.8 (2011): 111-116.

Yu, Taeho, and Il-Hyun Jo. "Educational technology approach toward learning analytics: Relationship between student online behavior and learning performance in higher education." *Proceedings of the Fourth International Conference on Learning Analytics and Knowledge*. ACM, 2014.