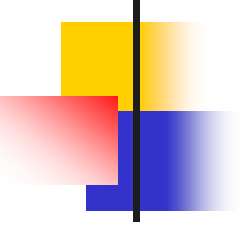




Learning Analytics

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- A few questions as thematic anchor



Analytic Insight

- You see which chapter the **class** finds difficult.
- You drill down to see which topic in the chapter the **class** finds difficult.
- You drill down and see which **students** in the class find a topic difficult.
- You drill down to which **type of question** in a topic a particular student finds difficult.



Do we need tests?

- You can tell **BEFORE** the test
 - Where the class will struggle,
 - the students that will succeed,
 - the topic some students need help on,
 - and the level of difficulty for a topic that needs to be re-taught.
- Do we actually need tests?
 - Skip the test and just hand out grades?



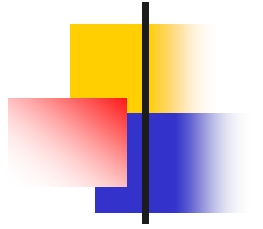
Skip the test?

- You cannot skip the test, because people like to believe they have freewill, they are not predictable, ...
- Should you check for cheating if a student test result does not match the analytic predictive model?
 - We can constantly add improvements to the analytic equation/model.



Could this change teaching?

- Sort results for difficulty ratio by topic
 - If you improve materials, target your work on the topics that helps the most
- Offer to help students who need it
 - Some students don't ask for help
- How do we teach without analytic data?
 - It is like having no map or GPS.



Basics



Analytics

- Analytics is used in business to improve performance by find important hidden patterns in business data.
 - Every transaction creates data.
 - Data is increasingly pervasive with computers.
 - How can we use data to improve?
 - What gold is in data awaiting discovery?



Learning analytics

- If we capture more data in education, can we use analytics to improve performance in education?
- Some examples:
 - Predict individual performance
 - Personalize for individual student needs
 - Improve accountability
 - Improve assessment feedback
 - Recommend resources
 - Improve student success (Papamitsiou & Economides, 2014)



Background to level set

- 2010 –launched a new Statistics course.
- Textbook, 60 video lectures, and millions of practice online questions.
- Every view of the textbook, lectures, or questions is **logged** for every student.
- Can we find pedagogical gold using learning analytics in this data?



Traditional course data

- For traditional courses, the weight and emphasis in math courses is usually *tests* and the final *course grade*.
- Educators assume the course grade reflects student learning from reading, lectures, and homework questions.



Learning analytics

- In learning analytics, we do not assume a course grade reflects textbook reading and/or homework questions.
- In analytics, we measure reading, video lectures, or homework and use the data to predict grades (ElAtia, Ipercel, & Hammad, 2012).
- We build equations to predict performance



Learning analytics granularity

- When using learning analytics, you must pick the level of data granularity?
- We use *topic* as the level of granularity.
 - A chapter consists of many topics.
 - Every time a student reads the book, watches a lecture, or does a question, we log the count, day, and the topic.



Adaptive learning

- We use adaptive learning.
- The difficulty of questions automatically adjusts to student ability.
- The pace of the course is *personalized* to student ability.
- Difficulty varies from 1 to 7 levels depending on the complexity of the topic.
- If you answer 4 questions correctly in-a-row at the most difficult level for the topic, you *complete* the topic and can move ahead.



Data capture for assessment

- For each student question, we log:
 - Topic
 - Level of difficulty
 - Correct or Wrong answer
 - Count of correct and wrong answers in a row
 - Topic Complete (yes/no)
 - (Computer = 3 correct in a row at high level for topic)
 - Total number of questions for level
 - Ease index for student for level
 - = number correct / total questions

High Level Results

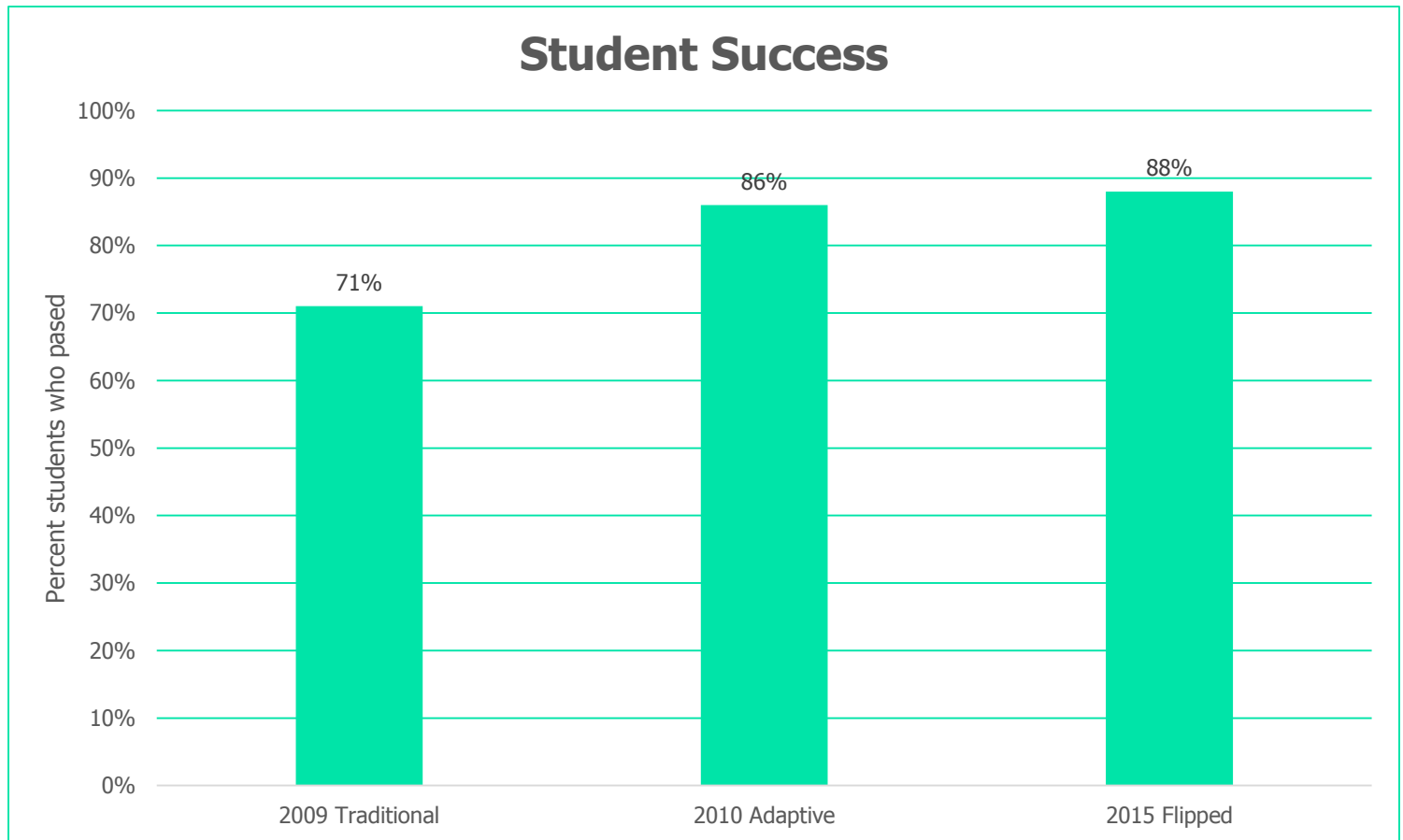


Chart 1: Percentage of students who passed the course using traditional lecture, adaptive learning, and flipped classroom.



Overview

- 2009 – Traditional
 - This is the benchmark
 - Standard lecture format
 - Sample size (n) = 143 students
- 2010 – Adaptive
 - Online questions. Personalized. Self-paced
 - n= 85
- 2015 and 2016
 - Adaptive learning plus online textbook and video lectures
 - High score, alert system for students in trouble
 - Flipped classroom, blended learning, hybrid learning
 - n = 249



Basic totals: Flipped classroom

- 249 Students in sample.
- Engagement
 - *Reading* -12,821 topics read
 - *Lectures* -10,444 video lectures seen
 - *Practice* -85,999 practice problems
- Students are engaged.
- Students found value in the resources.



Basic statistics – flipped classroom

- **Grades**

Mean	67% C+
Median	68%
Standard Deviation	17%
Maximum	97%
Minimum	0%

- The key result is that 88% of students passed the course which is very high for a statistics course.



Basic statistics

- **Textbook** – average topic count per student

Mean	47
Median	35
Standard deviation	44
Maximum	206
Minimum	0

- We measured 31 topics of the textbook using 249 students.
Students are reading topics multiple times.
 - reviewing textbook examples when working on questions, reviewing before a quiz is common.



Basic statistics

- **Video** lectures -average topic count

Mean	41
Median	29
Standard deviation	42
Maximum	185
Minimum	0

- We measured 31 topics of the lectures with 249 students. Students are watching lectures multiple times.
- Some students learn using the book, others prefer video lectures, or both. Students can learn using any resource.



Basic statistics

- **Practice** questions

Mean	319
Median	293
Standard deviation	144
Maximum	800
Minimum	2

- One reason for improved student success is the large number of practice questions.
- 293 unique questions per student using paper requires a professor grade 72,957 questions (249×293) by hand. Too much for a human. We need a computer.



Analytics - median per student by grade

<u>Grade</u>	<u>Book</u>	<u>Lecture</u>	<u>Practice</u>	<u>Complete</u>	<u>Average Grade</u>
A	53	24	365	33	85%
C	49	44	358	32	65%
F	21	19	173	20	38%

- Students with higher grades generally read more, practiced more, and completed more topics.
- Notice video lectures declines in the A grade.
- To *complete* a topic, the student must do 3 questions correct in-a-row at the highest level of difficulty.
- We measured 33 topics above.



Ease ratio

- We calculate the ease ratio for every topic and level of difficulty for every student. (High score = easier).

Topic	Average ease ratio by topic
Hypothesis	.62
Percentile	.62
Independence	.66
Discrete Variance	.69
Binomial distribution	.73

- We can use this analytic measure to improve instruction materials and time allocated for more difficult topics.
- Note: the literature calls (number correct/total) a difficulty ratio but some feel wrong/total shows difficulty and correct/total shows ease (Frey, 2006).



Ease ratio

- If we look at ease ratio within difficulty levels, insight is gained.
- Harder questions (levels of difficulty) may be easier for students (high ease ratios are easier)!

Topic	Level 1	Level 2	Level 3
Percentile	.52	.73	
Binomial	.76	.67	.73
Hypothesis Proportion	.53	.69	.66

- For percentile or hypothesis, it seems grasping the initial concept is more difficult than moving to a more complex question.



Predictive Analytics -Practice

- Does over-practice on questions improve success in statistics?
- Correlation shows a statistically significant relationship between number of *practice* questions and final *grade* at the 95% confidence level. (P-value = 0.0000)
- R^2 indicates **18%** of the final grade was explained by number of practice questions.



Predictive Analytics -complete

- To complete a topic, the student must correctly answer questions at all levels of difficulty.
- Correlation shows a statistically significant relationship between *completing* topics and *final grade* at the 95% confidence level. (P-value = 0.0000)
- R² indicates **43%** of the final grade was explained by number of topics completed.
- Clearly the **difficulty and variety** of questions completed is more important than the number of practice questions.



Predictive equation

- Final *grade* (percent) = $36.8 + 2.26(\textit{complete})$
- For each topic completed, final grade will increase by 2.26%
- Multiple regression of both *complete* and *practice* variables to predict *grade* did not improve the R² of .43 value (P-value = 0.000) provided by *complete* alone, so we can simplify the equation to one variable.

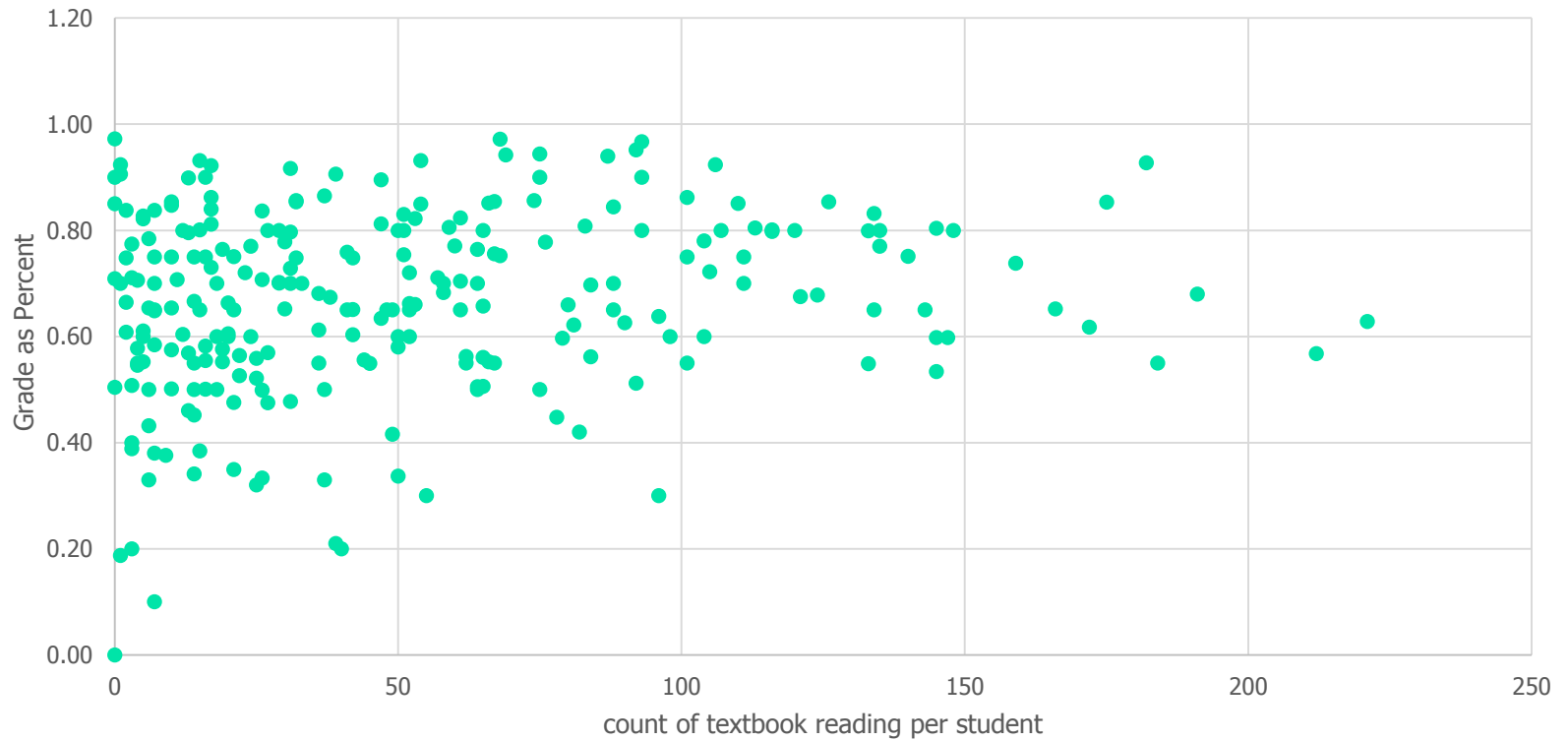


Book and Video lectures

- As a professor, my expectation is any view of the textbook or video lectures will increase understanding and eventually the grade.
- Analytic regression analysis showed **no relationship** between the count of textbook or video access and final grade.
- A graph of textbook and grade, or video and grade, does not show a clear linear or non-linear relationship. The chart shows no relationship.

Grades and textbook ($r^2 = .03$)

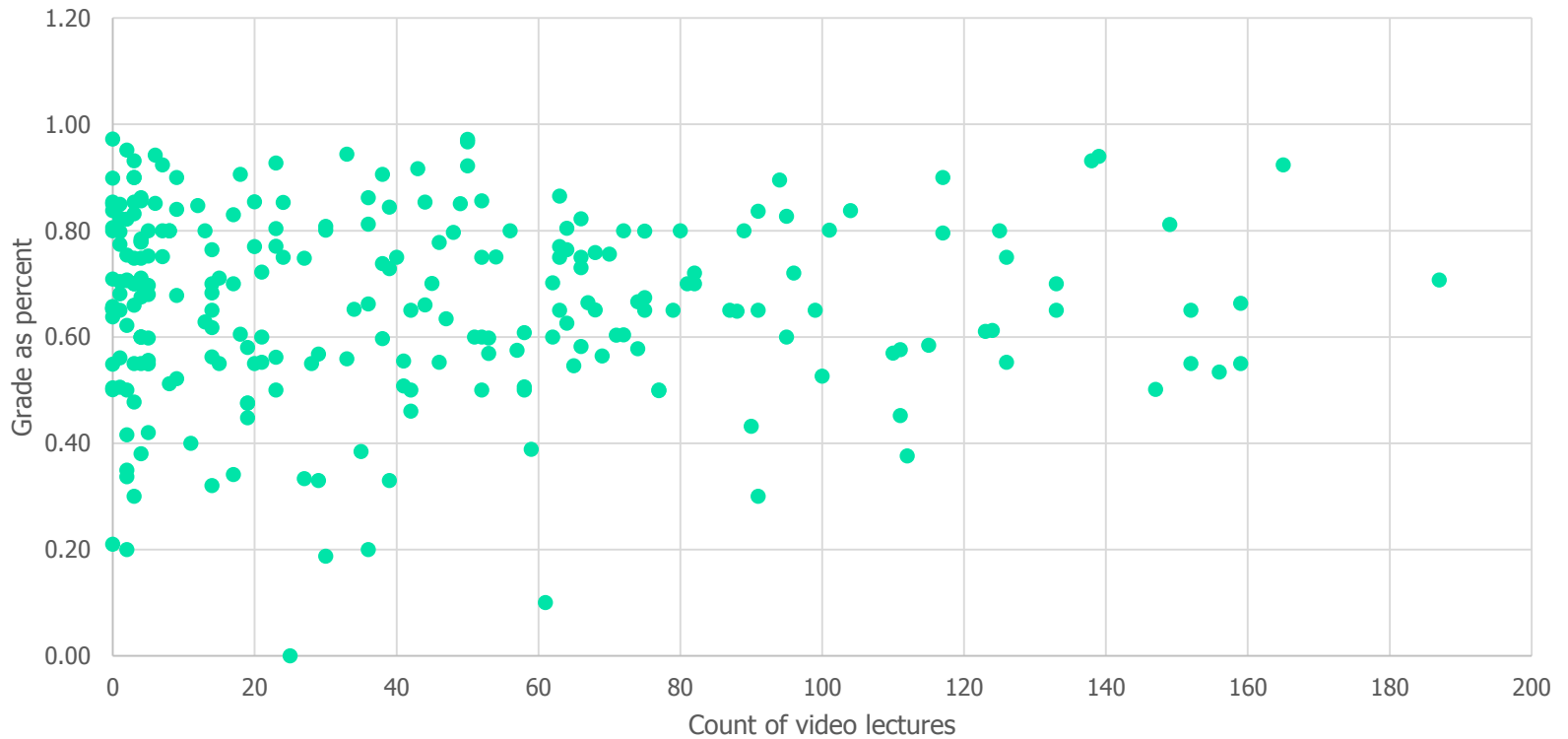
Grades and Textbook





Grades and video ($r^2 = 0.00$)

Grades and Video Lectures





Book and video analytics

- We looked at this lack of relationship between textbook and grade as follows:
 - Multiple regression
 - Logistic regression using pass-fail grade
 - Trimmed 10% of outliers
 - Created a video+book index
 - Regression by grade cluster: A,B,C,D,F.
- No statistically significant effect ratio was found for book/video and final grade.



Book/Video and Grade

- My thought is too many uncontrolled variables.
 - Prior learning, help from professor, help from friends, access to Wikipedia, ...
- We need a controlled experiment for the book and video variables to prove a relationship.
 - Pre-assessment
 - Read one topic.
 - Post-assessment.
 - Use a controlled environment.
- My prior bias was so strong I expected that under any condition you could see a relationship.
- Does reading matter?



Controlled experiment and Adaptive learning

- Adaptive learning personalizes learning to individual needs.
- Controlled experiments standardizes learning to control for all variables except the intervention variable.
- There is a conflict of goals between individual adaption and experimental control.



Student survey on Video

- **Question: Why you want the video lectures?**

Mark ALL answers that apply.

- If I miss a class because of work responsibilities 63%
- If I miss a class due to illness 56%
- If I am late to a class and miss material 63%
- Videos are helpful as English is a 2nd language. 56%
- Video help if you sleep in or work on an important assignment instead of coming to class. 38%
- I like the videos to check for mistakes in the practice questions. 81%



Dashboard (www.growingknowing.com, 2015)

[Statistics](#) | [How To](#) | [About Us](#) | [Help](#)

Dashboard for Professors showing Practice Progress by Topic

Section: TTT
Date: 16-November-2016
Active Students: 3
Inactive Students: 0

Topic Name	Number of Students Incomplete
Mean	2
Median	2
Mode	2
Range	3
Variance	3
Standard Deviation	3
Skewness	3
Coefficient Variation	3
Empirical Rule	3



Dashboard

- With the dashboard, a professor can see which topics the class finds difficult.
- The professor can re-teach or provide more time for difficult topics.



Dashboard – drilldown

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Dashboard for Professors showing Practice and Exercise Progress by Student

Section: TTT
Date: 16-November-2016
Active Students: 3
Inactive Students: 0

Student Name	Student E-mail	Count of Complete	
		Practice Topics	Exercises
Dancer, Amanda	amanda@gmail.com	1	0
the Kid, billy	billy@gmail.com	3	0
Tester, Test	test@gmail.com	0	0

This report shows which students need help. Some of these students may be reluctant to seek help.

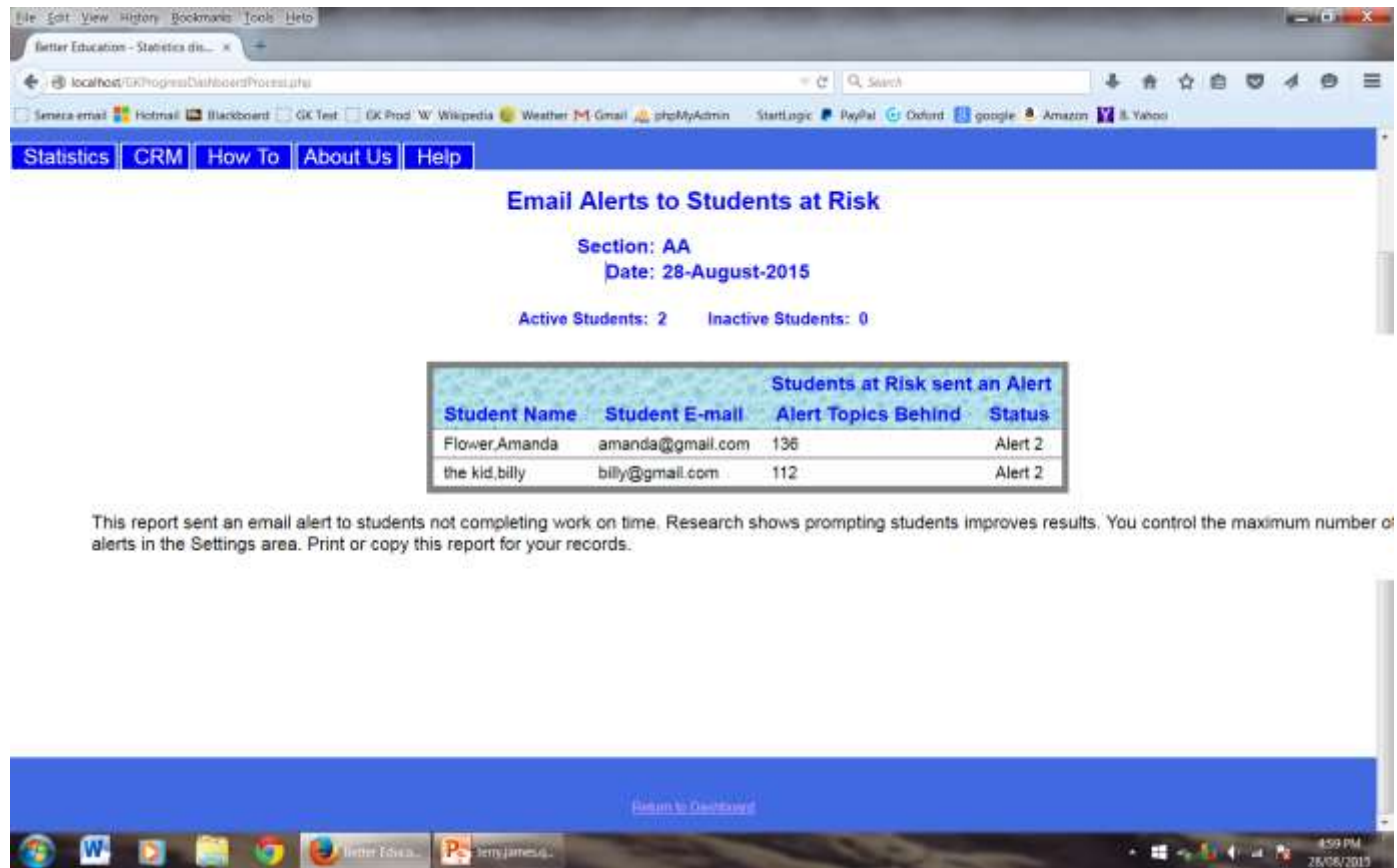
[Return to Dashboard](#)



Dashboard - drilldown

- A professor can drilldown to find who in a class finds the topic difficult.
- The professor can then do an intervention.
- Some students are reluctant to ask for help.
- **A professor can predict how the class will do and who will succeed BEFORE the test.**
- Note: the dashboard reports provided and student names show fake results to protect student privacy. (www.growingknowing.com, 2015)

Alert (www.growingknowing.com, 2015)



Statistics CRM How To About Us Help

Email Alerts to Students at Risk

Section: AA
Date: 28-August-2015

Active Students: 2 Inactive Students: 0

Students at Risk sent an Alert			
Student Name	Student E-mail	Alert Topics Behind	Status
Flower, Amanda	amanda@gmail.com	136	Alert 2
the kid, Billy	billy@gmail.com	112	Alert 2

This report sent an email alert to students not completing work on time. Research shows prompting students improves results. You control the maximum number of alerts in the Settings area. Print or copy this report for your records.

[Return to Dashboard](#)



Alerts

- The system tracks performance so multiple levels of automated alert can be sent to students.
 - Does the student need attention?
 - Help? Encouragement? A plan?
- We do not have a large enough sample to have statistical significance (not enough people fail!)
- Alerts can be tailored by each professor.
- About half the students who get an alert make a commitment to catch-up. They pass the course.
 - Currently a first alert is sent if you are 25% behind schedule

High score –highly motivating

Dashboard for Professors showing Practice High Scores

Section: BB
Date: 27-August-2015

Active Students: 16 Inactive Students: 0

Nickname	Score
House Targaryen	42,333
Banana	38,351
Satv	37,046
Tim	36,152

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Summary – Learning Analytics

- We improved student success significantly.
- We can predict performance using an equation.
- We see who needs intervention before the test.
- We can automatically alert students before it is too late.
- Analytics allows us to sort topics by difficulty for the class, student, or question.
 - We can allocate time when most needed
- More research is need into textbook and video lecture analytics.



References

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- Frey, B. (2006). *Statistical hacks: Tips and tools for measuring the world and beating the odds*. Sebastopol, CA: O'Reilly.
- Papamitsiou, Z. & Economides, A. (2014). Learning Analytics and educational data mining in practice: A systematic literature review of empirical evidence. *Educational Technology & Society*, 17 (4), 49-64.