On the Development of an Automated Course Assessment Tool (ACAT)

Timothy Kostar, Linda Marquis, Nicholas Bertozzi
School of Engineering and Computer Science
Daniel Webster College

Kurt Hamilton
AeroSat Corporation

Abstract

Higher education assessment is typically addressed at three levels: course, program, and institution. While commercial products for aid in the assessment process exist, a developmental Automated Course Assessment Tool (ACAT), tailored to the needs of the author's institution, is presented. Primary features and functionality include simple and efficient set-up of course outcomes and the associated weighted mapping of performance indicators, "No Submit Analysis," basic statistical analysis, basic correlation studies, and auto-generation of a course outcomes assessment summary table. The work is on-going, with additional features and functionality to follow, including product integration with program-level assessment practices.

Introduction

Assessment of the effectiveness of higher education is a continuous improvement process. Assessment is typically addressed at three interconnected levels: course, degree program, and institution. Indeed, various accreditation organizations (NEASC, 2012; ABET, 2013) insist on continuous assessment through established standards and guidelines. To aid in the assessment process, numerous commercial software and/or service products are available (SmartEvals, 2013; Taskstream, 2014; LiveText, 2014; Insight Assessment, 2013). However, any given product has both desired and undesired features and functionality. In addition, the complexity of some products might even be viewed as "overkill" if one seeks direct and simple tools to aid in assessment -- tools which will be used effectively and thoroughly by faculty, staff, and administration. Numerous institutions have developed tailored systems, typically computer based, to aid in the process. The works of Poger (2006), Boff (2009), Laverty (2010), and Elnaffar (2013) summarize typical examples of such efforts. This paper summarizes the on-going development of a course-level assessment tool, termed Automated Course Assessment Tool (ACAT).

Background and Motivation

Historically, course-level assessment at the author's institution is completed after a semester ends. In summary, this process involves generation of a table that summarizes the percentage of students who met, partially met, or failed to meet each course outcome (more on this later). This summary is carried out for each Performance Indicator (PI) assigned to a given outcome (assignments, exams, etc.). In addition, final grade distribution is tabulated and general observations made. Finally, the course instructor formally documents the response to three questions: What worked or did not work? What changes were made during the semester? What should be done differently the next time the course is offered? A sample course outcomes analysis is provided in the Appendix A for a freshman first-semester engineering design course.

The primary intent of this process is to facilitate a continuous course improvement process which is supported by basic data (the aforementioned table with met, partially met, failed to meet summary data). While the intent is noble, some shortcomings to this process include the following:

- Consumes considerable faculty time
- Compliance is weak (especially with adjunct faculty)
- Does not fully utilize all available data in the course assessment process
- Does not facilitate "real time" assessment
- Does not allow for efficient "temporal" studies on course improvement to be conducted
- Is not easily and efficiently "fed into" program-level assessment

To address these weaknesses, an easy-to-use yet powerful software package to aid in course assessment, one that was tailored to our institutional needs and culture, was put under development.

ACAT Overview

The Learning Management System (LMS) used by the author's institution is open source code, allowing for external programs to access the database (e.g., grade book data). As a result, once the user (course instructor) logs into ACAT, a list of all his/her courses is displayed. To start, and typically done at semester's beginning, the instructor will select a course and "copy and paste" the course outcomes from the course syllabus into windows within ACAT. Figure 1 supplies a screen shot showing that a course has been selected and the relevant information easily "copied and pasted" into the ACAT database.

The next simple yet important task involves assigning PIs and their weightings to the entered course outcomes. Since ACAT identifies not only the data recorded in the LMS grade book but also the hierarchical structure of the established grade book, this mapping and weighting of PIs to course outcomes may be at any level the instructor wishes. For example, "Exam #2" may be mapped (with weighting) to a program outcome or, if the LMS grade book is structured in such a way, a particular problem from an exam (or any assignment) may be mapped with weighting.

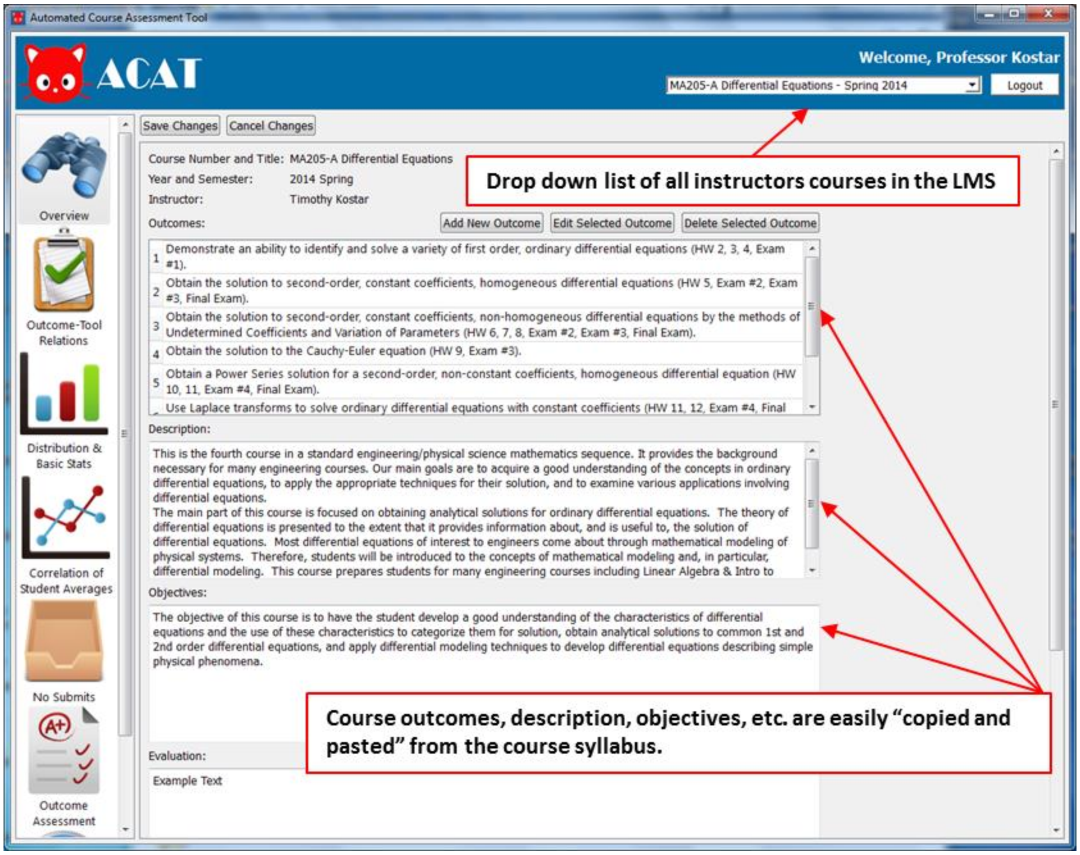

Figure 1. Screen shot showing the drop down list of all the instructor's courses within the LMS database and the simple "copy and paste" feature to inform ACAT of the defined course outcomes.

To facilitate this mapping, "Outcome-Tool Relations" is selected from the list shown on the left of Figure 1. The course outcomes, having already been entered into ACAT, are listed (Figure 2). As a simple example, suppose the LMS gradebook has been structured to have the resolution of PI categories as Homework, Exams, Project, and Final Exam (Figure 2). The instructor then selects a course outcome for editing and selects which PIs (as defined in the LMS grade book) will be mapped to the outcome. In addition, a weighting may be applied to any PI based on its relative importance to assessing a student's mastery of a course outcome. For example, as shown in Figure 2, Homework 2, 3, and 4, each with a 15% weighting, and Exam #1, with a 55% weighting have been mapped to Outcome #1. Finally, as shown in Figure 2, rubric-based PI tools (as opposed to conventional grading) may also be mapped to outcomes and weighted.

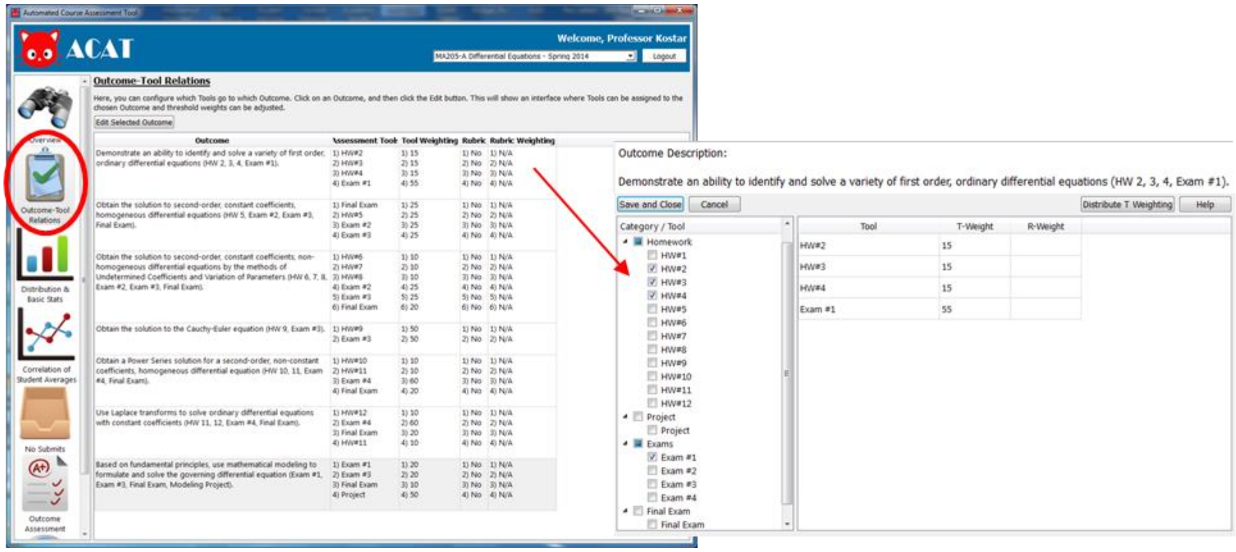

Figure 2. Screen shot showing the "Outcome-Tools Relation" window. After selecting Outcome #1 for editing, Homework 2, 3, and 4, each with a 15% weighting, and Exam #1, with a 55% weighting, have been mapped to the outcome. In this example, no rubrics are associated with the outcome.

Another ACAT feature is the "No-Submit Analysis." If a student fails to submit an assignment, the grade is entered as a zero in the LMS grade book. (If a student has withdrawn from a course, the LMS grade book cell is left blank for ACAT identification of the withdrawal.) Figure 3 shows an example of a "No-Submit Analysis" for our sample course. A red cell indicates a no-submit for any particular assignment, and a black cell indicates the assignment was not submitted because the student withdrew from the course. Some simple observations may be made from this analysis. As an example, seven (7) students did not submit Homework #9. As such, the potential cause of this may be investigated. As will be discussed in more detail, ACAT allows the instructor flexibility in determining whether to include "no submits" and withdrawals in an outcome assessment.

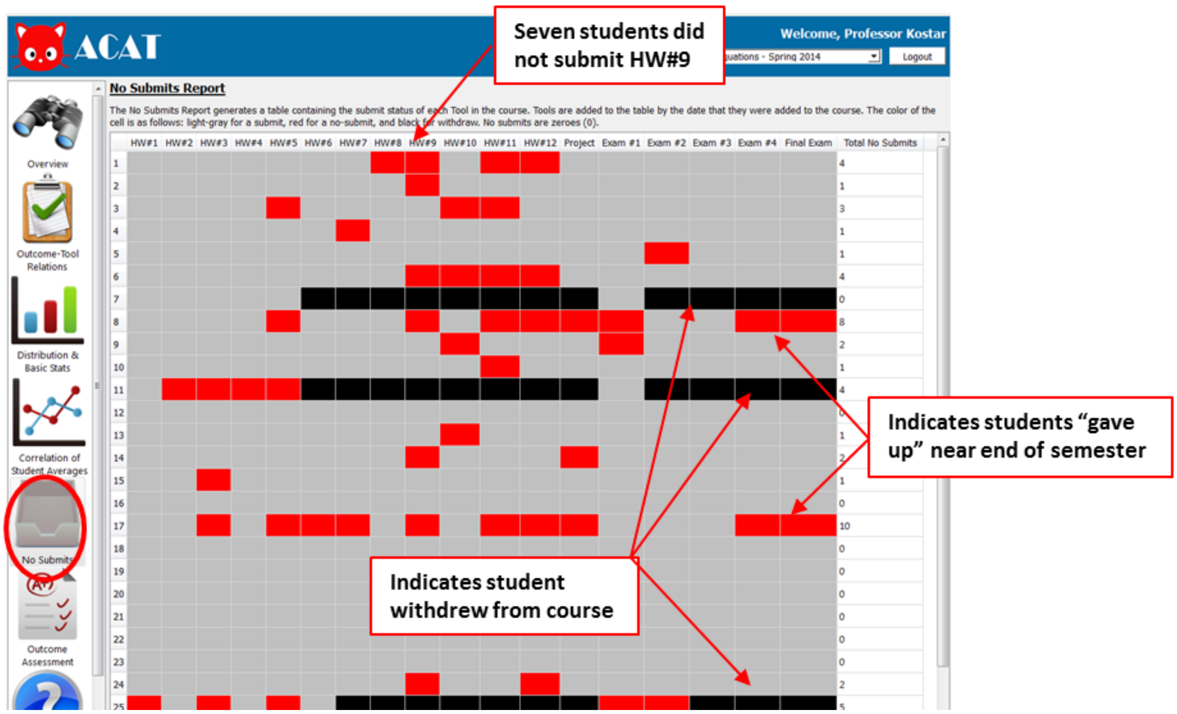

Figure 3. Screen shot showing the "No Submit Analysis" window. A red cell indicates the student did not submit the particular assignment, while a black cell indicates the student withdrew from the course during the withdrawal period.

Next, ACAT easily facilitates basic statistical analysis of data, even pooled data. For example, suppose we wish to look at the basic statistics of the pooled data "all in-term Exam Grades". In addition, we do not want to include grades associated with a withdrawn student or grades of zero (no submission). Figure 4 shows the results of the basic statistical analysis including the histogram count, mean, and standard deviation. (Note: one has the option of varying the bin sizes.) Such analysis is useful in many ways, including checks for normality of distributions and trends in distributions over time.

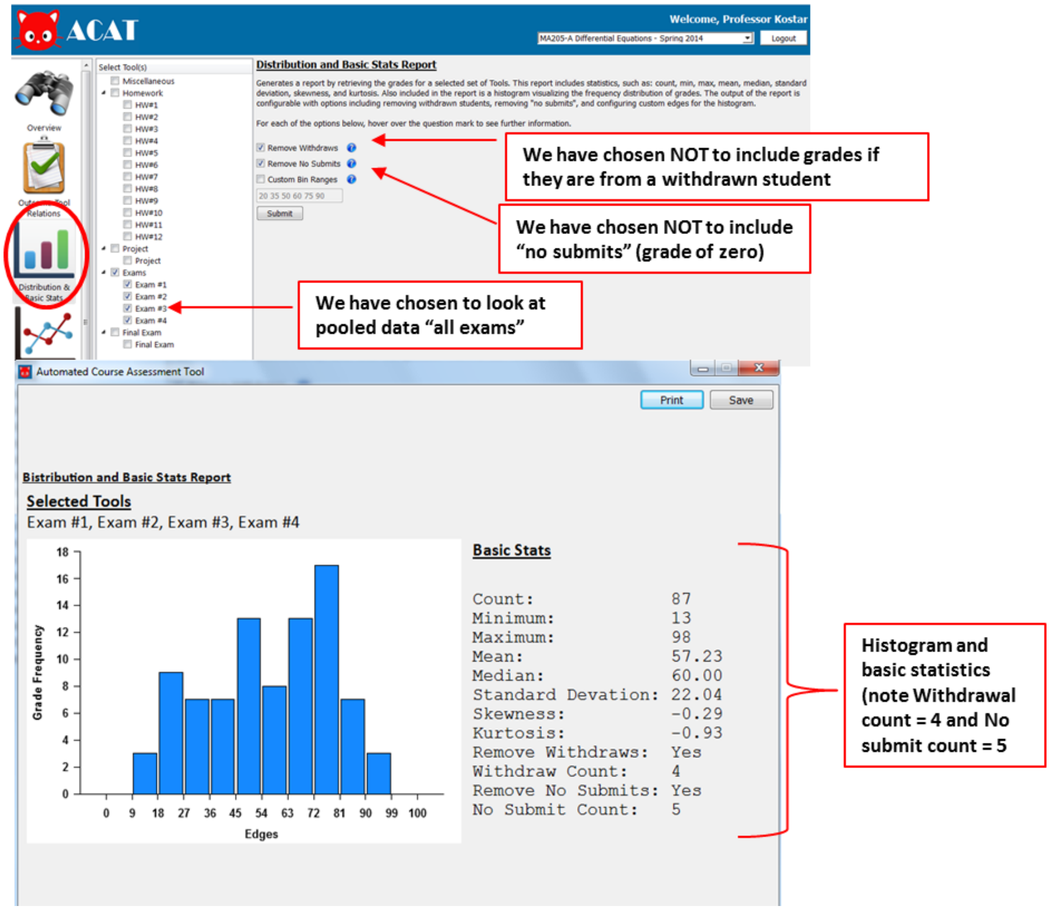

Figure 4. Screen shot showing the basic statistical analysis functionality of ACAT. In this example, we have selected the pooled data of Exam 1 through 4 and have chosen not to include student withdrawals or no submissions.

In addition, ACAT easily facilitates simple correlation studies. For example, suppose Homework Assignments 1 through 4 are practice for the understanding level evaluated in Exam #1. It is well known that, in an ideal world, a student who does well on homework should also do well on the related exam, and vice versa. As can be seen in Figure 5, a group of students has done well on the practice homework but performed poorly on the associated exam. Knowledge of this trend would likely motivate further investigation to determine the cause.

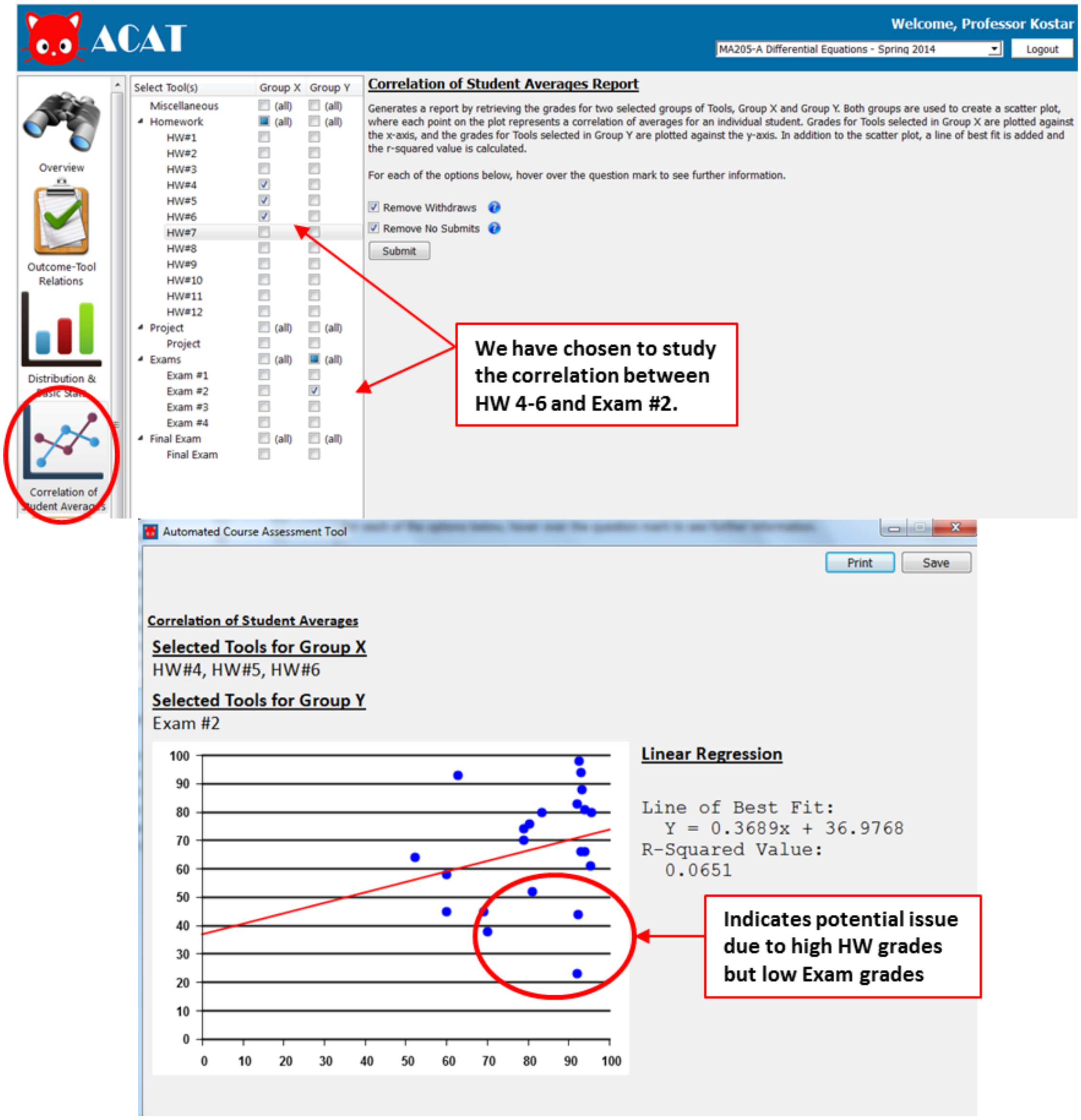

Figure 5. Screen shot showing a simple correlation study between homework grades and associated exam grades. Such studies are useful in identifying issues that might be investigated.

Finally, ACAT may be used to automatically generate a summary table showing percent met, partially met, and failed to meet for each course outcome and the assigned Performance Indicators (Figure 6). This table may then be manually augmented with the instructor's comments on potential future plans to improve obtainment of any given course outcome.

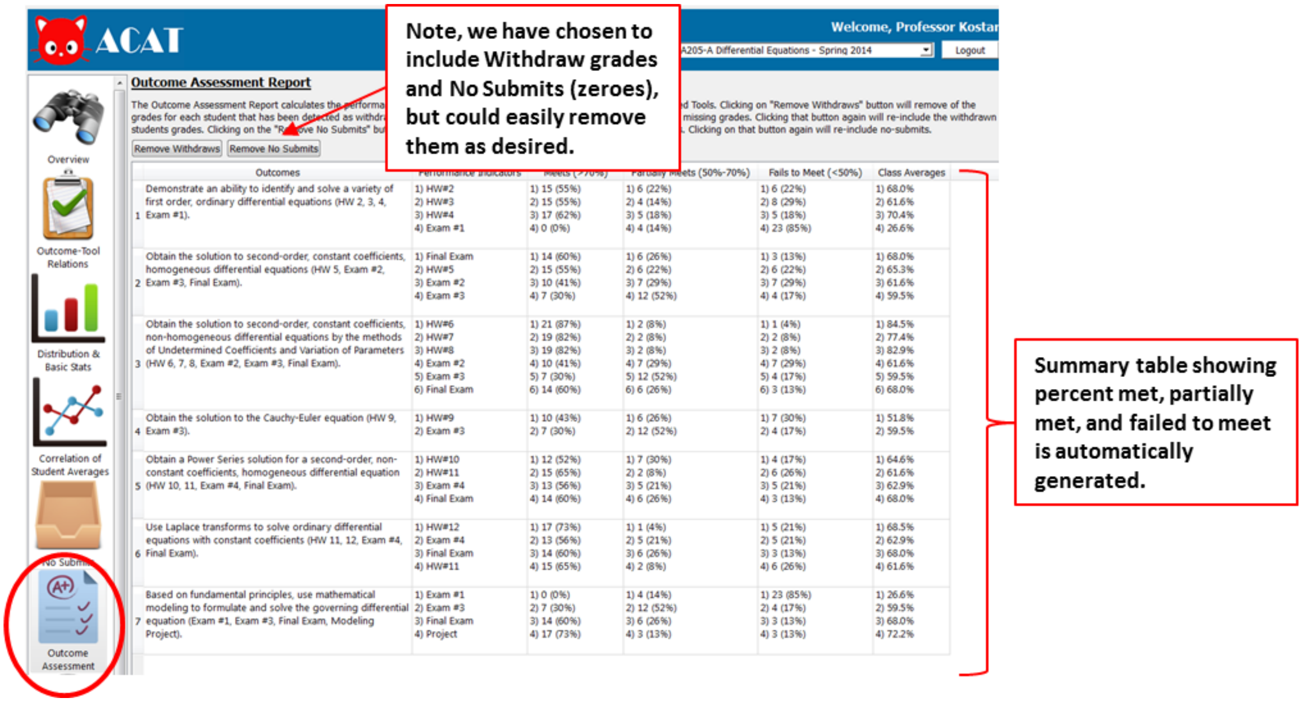

Figure 6. Screen shot showing an auto-generated summary table indicating the percent met, partially met, and failed to meet for each course outcome and each mapped Performance Indicator.

Conclusions and Discussion

While commercial software and/or service packages are available to aid in assessment at all levels, they sometimes prove costly, complex, and generic. An in-development Automated Course Assessment Tool, tailored to the needs of the author's institution, has been presented. ACAT's features and functionality include:

- Simple and efficient set-up of course outcomes and the associated weighted mapping of Performance Indicators.
- "No Submit" analysis.
- Basic statistical analysis.
- Basic correlation studies.
- Auto-generation of the summary table of course outcomes met, partially met, and not met.

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Additional ACAT features not directly discussed include the ability to generate a Course Assessment Report with selected support analysis, and the ability to assess course outcome obtainment in "real time" for potential in-term changes.

Future work includes:

- The addition of a weighted performance indicator (and rubric) row within the summary table for a global weighted view of outcome obtainment.
- Real-time (while the semester is in progress) basic statistical analysis for each course outcome (Histogram, mean, standard deviation, etc.) that displays how well any given outcome is being met per its mapped and weighted performance indicators.
- Year-to-year historical comparison of student course outcome achievement to help determine the impact of instructional revisions and enhancements.
- A summary table of student versus course outcome, where the instructor may easily apply a rubric-like assessment with respect to how well individual students are obtaining each outcome.
- An extension of the tool to tie-in with program level assessment, such as mapping of select courses and their content to the associated program outcomes.

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Appendix A

Outcomes Matrix for EG110 Engineering Design I (27 Students)

Outcomes	Performance Indicators	Results			Analysis Notes	Future Plans
		Meets (>70%):	Partially Meets (50%-70%):	Fails to Meet (<50%):	Class Averages:	
The students will begin to develop the ability to use the engineering design process as a method for solving complex, open-ended problems (Design Project)	Overall project score	26 (96.3%)	1 (3.7%)	1) 0 (0%)	Average: 85% Note that 8 students out of the 35 who started the course either withdrew or stopped attending and so were not included in these averages.	The presentation on the design process was revised this semester. Additional material will be added next semester in order to better prepare the students for the design process in Design III and the capstone sequence. Note that the overall average for the project was significantly better this year than last year.
The students will develop engineering graphics skills and integrate the design process with graphics and solid modeling as the method for developing and communicating the solution of engineering problems. (Drawing Assignments, Drawing Quizzes, and Design Project)	1) Drawing Assignments 2) Design Projects (Drawing component)	1) 18 (66.7%) 2) 27 (100%)	1) 8 (29.6%) 2) 0 (0%)	1) 1 (3.7%) 2) 0 (0%)	1) 80.6% 2) 91%	The modeling and graphics for the design projects was well done. For the most part students with low averages in the drawing assignments failed to turn in all the drawings, which obviously hurts their average. The use of the online working drawing review module seems to be effective in improving the project graphics and will be continued.
The students will develop the sketching techniques required to visualize and characterize three dimensional objects on a two dimensional medium. (Sketching Assignments)	Sketching Assignments	20 (74.1%)	3 (11.1%)	4 (14.8%)	Average: 74.3%	Add some online sketching instruction videos.
The students will be able to design, using appropriate software, a visually effective presentation. (Topic Presentations, Milestones and Final Project Presentations)	1) Topic Presentations 2) Final Project Presentations (communications component)	1) 20 (74.1%) 2) 27 (100%)	1) 7 (25.9%) 2) 0 (0%)	1) 0 (0%) 2) 0 (0%)	1) Average: 77% 2) Average: 93.5%	This semester, increased time and emphasis on presentation dry runs contributed to the improved quality of the design presentations. This emphasis will be continued. The topics presentations were done earlier in the semester, so as expected, the presentations were not as

Outcomes Matrix for EG110 Engineering Design I - Continued

Outcomes	Performance Indicators	Results			Analysis Notes	Future Plans
		Meets (>70%):	Partially Meets (50%-70%):	Fails to Meet (<50%):	Class Averages:	
						good as the final design presentations. These topics presentations were also preceded by dry runs.
The students will be able to deliver a presentation that is well organized, complete, and conveys information clearly and concisely. (Topic Presentations, Milestones and Final Project Presentations)	1) Topic Presentations 2) Final Project Presentations (communications component) 3) Final project presentations (technical component)	1) 20 (74.1%) 2) 27 (100%) 3) 27 (100%)	1) 7 (25.9%) 2) 0 (0%) 3) 0 (0%)	1) 0 (0%) 2) 0 (0%) 3) 0 (0%)	1) Average: 77% 2) Average: 93.5% 3) Average: 84.7%	See previous outcome. Continue increase emphasis on dry runs. Student performance on the results and conclusions sections was poor. Additional instruction in these sections will be added.
The students will be able to write a report in clear, precise language, using the standard parts of an engineering report. (Design Project Report)	Design Project Report (communications component)	27 (100%)	0 (0%)	0 (0%)	Average: 86.9 %	Additional up-front instruction on report content and format was given. Overall average is improved from last semester. Continue to expand online resources next semester.
The students will be able to apply fundamental engineering concepts involving free-body diagrams, tensile and shear stress, center of mass, torque and power curves for DC motors, power requirements, and multi-stage gear box design. (Engineering Fundamentals Quizzes and Design Project)	1) Engineering Fundamentals Quizzes 2) Design Project (technical component)	1) 24 (88.9%) 2) 27 (100%)	1) 3 (11.1%) 2) 0 (0%)	2) 0 (0%) 3) 0 (0%)	Average: 82.6 Average; 83.3%	Engineering fundamentals quizzes average was significantly improved. No explanation for this.

Outcomes Matrix for EG110 Engineering Design I - Continued

Outcomes	Performance Indicators	Results			Analysis Notes	Future Plans
		Meets (>70%):	Partially Meets (50%-70%):	Fails to Meet (<50%):	Class Averages:	
The students will function as responsible, contributing member of a design team. (Analysis of relative contributions of team members)	1) Analysis of relative percent contributions of team members – See table below	1) (Standard deviation<5) 8/11 (72.7%)	1) (Standard Deviation 5-10) 2/11 (18.2%)	1) (Standard Deviation >10) 1/11 (9.1%)	Average Standard Deviation: 3.26 Note that 7 students out of the 35 who started the course either withdrew or stopped attending and so were not included in these averages.	The results were improved this semester with seven teams reporting uniform contribution of their members. We utilized the team creation and peer evaluation tool called CATME from Purdue for the first time. This tool was used for the selecting the members of the teams. However, it was only used once for midsemester team evaluation. Increasing the frequency should improve the effectiveness of this tool. In our last evaluation of the course we recommended more up-front emphasis on team building and project management skills. Due to the workload of the teaching team we were not able to pull this off this semester but will try again next time.
The students will develop proficiency in the use of a variety of software tools such as Mathcad and Excel that are useful for engineering communication and analysis. (Computer Skills Assignments)	Computer Skills Assignments	26 (96.3%)	1 (3.7%)	0 (0%)	Average: 97.2%	Working well, no change planned.
The students will acquire a knowledge of the fundamental principles of the ABET Code of Ethics of Engineers. (ABET quiz)	ABET quiz	27(100%)	0 (0%)	0 (0%)	Average: 100%	Working well, no change planned.

Outcomes Analysis for EG110 Engineering Design I – Continued

Individual Team Member Percent Contribution

	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6
Member A	33	45	50	40	50	33
Member B	33	45	50	20	50	33
Member C	33	10		40		33
Standard deviation	0	16.5	0	9.4	0	0

	Team 8	Team 9	Team 10	Team 11	Team 12	
Member A	50	57	33	53	50	
Member B	50	43	33	47	50	
Member C			33			Standard Deviation Ave.
Standard deviation	0	7	0	3	0	3.26

Observations about the class
Started the course – 35
Finished the course – 27
Grade breakdown:

A	A-	B+	B	B-	C+	C	D	F	W
11	3	2	0	0	4	5	1	6	3

What worked well? This semester, increased time and emphasis on presentation dry runs contributed to the improved quality of presentations. Thirteen new Jing videos for SolidWorks instruction, tips, and review were created and feedback from the students indicated they were helpful. Additional online resources were developed for report writing.

What changes did you make during the Academic Semester? This semester we utilized the team creation and peer evaluation tool called CATME from Purdue for the first time. This tool was used for the selecting the members of the teams. However, it was only used once for mid-semester team evaluation. Increasing the frequency should improve the effectiveness of this tool. As can be seen from the Individual Team Member Percent Contribution results, seven teams reported uniform contributions from their members, which is a great improvement. It seems unlikely that this improvement could be attributed to the use of CATME alone.

What would you do differently next time?

- In our last evaluation of the course we recommended more up-front emphasis on team building and project management skills. Due to the workload of the teaching team we were not able to pull this off this semester but will try again next time.
- Next year we plan to use peer evaluation earlier and more often.
- The presentation on the design process was revised this semester. Additional material will be added next semester in order to better prepare the students for the design process in Design III and the capstone sequence.