Multi-Purpose Student Tracking System

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Abstract

Large enrollment engineering programs are usually managed on the basis of faculty and administrator experience. Unfortunately, this experience may be outdated, misinterpreted, or disproportionately influenced by outlier and atypical cases. In order to avoid these problems and to help manage large enrollment programs, a decision support system was developed to assist in identifying overall trends, detecting struggling students and enforcing departmental rules. A framework for a degree program management system has been developed. The important issues have been identified and the design features to address them have been discussed. Potential analyses are illustrated. Some of the results for the Bachelor of Science in Industrial and Systems Engineering at the University of Florida are presented, such as the grading anomalies in a senior-level course and the effects of increasing the ”pass” threshold of Calculus 2 upon the potential degree completion. The program identified that the student performance in the seven “critical tracking” courses closely predicts eventual overall GPA.

Keywords

Program management, decision support, student tracking, enrollment trends, progress monitoring

Motivation

Over the last few years several engineering departments at the University of Florida such as Industrial and Systems Engineering, Chemical Engineering and Mechanical Engineering have experienced a significant increase in undergraduate enrollment. This has added to the administrative burden of the faculty in charge of advising undergraduates and tracking their progress, and maintaining departmental standards. Coupled with a lack of sufficient advising personnel and a user-friendly and effective student management software, it has become quite challenging to identify trends in enrollment, grading and student performance, to detect struggling students early on so that corrective action can be taken and to simply enforce existing department and college rules and requirements.

Without the ability to obtain meaningful and actionable data, it is difficult to be aware of and adapt to changing circumstances, do strategic planning and justify the changes made and verify their effectiveness. Consequently, the need for a comprehensive program management system has become quite clear. This is an issue that the University of Florida is in the process of addressing. However, changes in a large institution occur only after careful planning and time consuming deliberations. Furthermore, it is a challenge to develop a common decision support system for program management for a large number of departments with different needs and focus. The resulting product may not be tailored to the needs of any particular department. Due to these reasons, a decision has been made to develop a framework for a program management system and to implement it for the Department of Industrial and Systems Engineering at the

University of Florida. This study aims to identify the specific issues that need to be addressed and to come up with the best design features and user interface to address them.

As stated previously, the main areas of focus of this study are student tracking/advising, curriculum improvement and enforcement of department rules. As the first step, a set of specific questions and issues of interest have been established in each area. The purpose of the program management system is to study and answer them. They are:

- Studying grade inflation and determining the courses that contribute to it,
- Analyzing long term and periodic course enrollment patterns,
- Studying the accuracy of critical tracking courses in predicting the success of students in professional courses,
- Analyzing the potential impact of changes in the minimum grade requirement of individual critical tracking courses on the retention rate,
- Identifying students who are currently or about to be in violation of various department and college rules,
- Identifying students who are accumulating credits without making sufficient progress toward their degree,
- Devising a more accurate method for measuring individual student performance compared to peers,
- Developing a more user-friendly and interactive way to view a student's academic record.

Design Specifics

Following the principles of proper decision support system design, emphasis has been placed on creating a user-friendly design that focuses on visual delivery of results. Consequently, the software developed utilizes, whenever possible, interactive and customizable charts embedded in various screens. The program management system being developed is intended to facilitate the study and analysis of the previously described issues which are handled by the following application components:

a) *Grade and Enrollment Tracking* (to detect long term and periodic trends in course enrollment and grades)
b) *Roster Quality Analysis* (to analyze student quality patterns in course enrollment)
c) *Correlation Analysis* (to evaluate the predictive value of critical tracking courses)
d) *Critical Tracking Impact* (to analyze the impact of changes to critical tracking requirements)
e) *Current Students* (to evaluate individual student performance and to view the detailed academic record)
f) *GPA and Credit Hour Analysis* (for the analysis of aggregate student grade and credit hours)
g) *Progress Monitoring* (to identify students who are off-track)
h) *Repeat Tracker* (to identify students who are in danger of violating critical department rules)

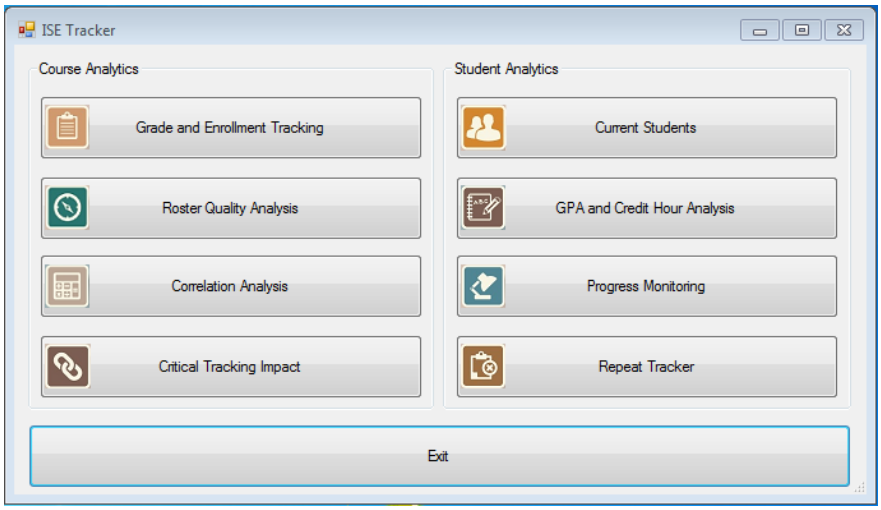
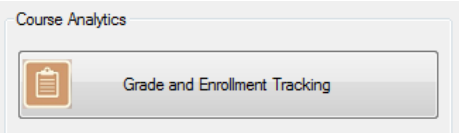


Figure 1. Main menu.

Items (a) - (d) fall under Course Analytics whereas (e) - (h) are grouped as Student Analytics (figure 1).

Grade and Enrollment Tracking



The *Grade and Enrollment Tracking* option in Course Analytics helps the user detect long term and periodic trends in course enrollment and grades.

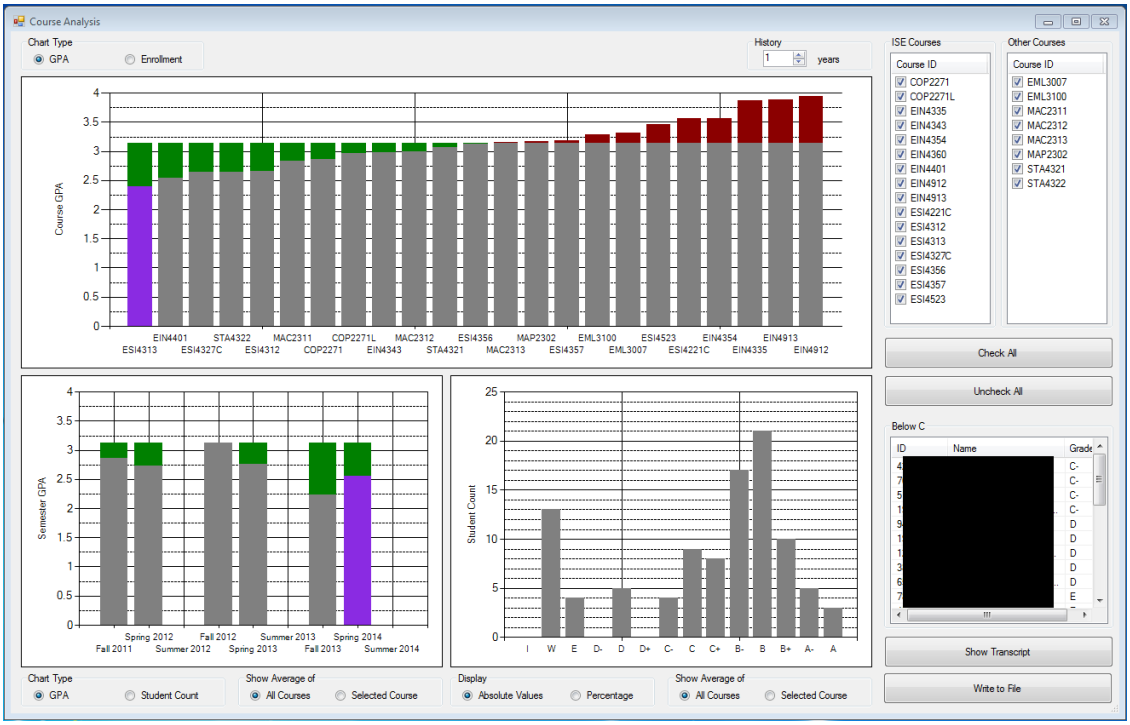


Figure 2. (Course) Grade and Enrollment Tracking screen.

The upper half of the screen (figure 3) displays a sorted list of grade averages for selected courses. This chart allows the user to identify courses with historically high grade averages as well as low. The red bars indicate that a course has above average grades whereas a green bar indicates the opposite.

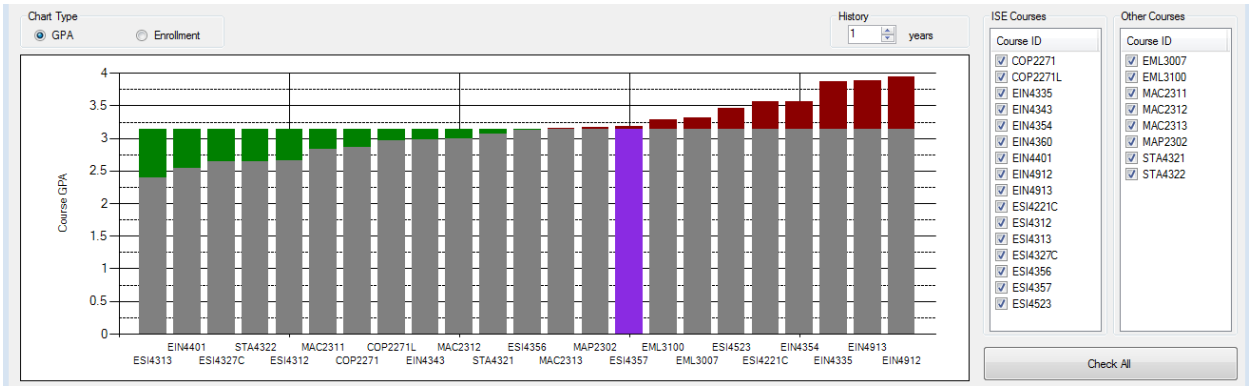


Figure 3. Grade distribution by course.

In order to obtain more detail on a specific course, the user selects that course by clicking on it in the chart which highlights the course in a different color. The bottom half of the screen provides a semester by semester breakdown of the grade average for the selected course, going back as far as nine semesters. This allows the user to detect grading patterns or anomalies. For example, the left chart in figure 4 indicates that for ESI4357 (Web based Decision Support Systems) grades in summer are significantly higher than grades in fall and spring. This may be due to variations in grading policy or student quality. How the variation of student quality can be analyzed is later explained in the Roster Quality Analysis section.

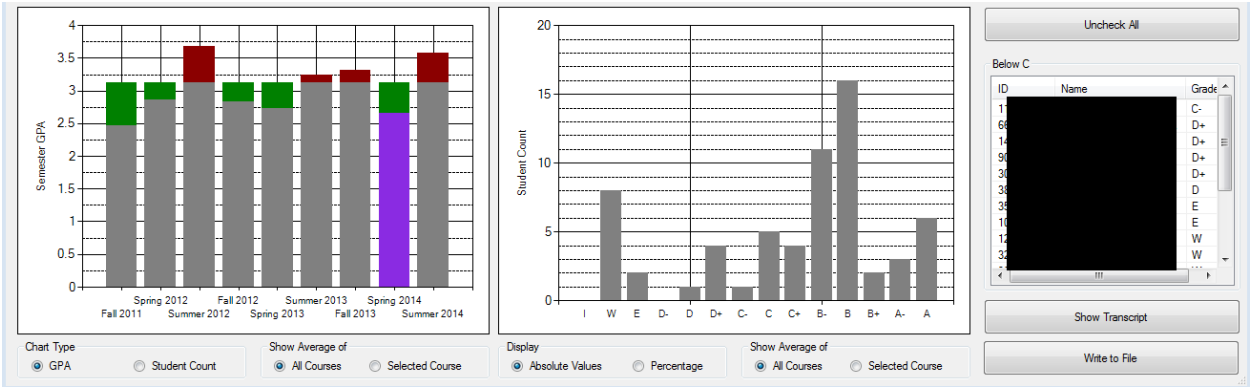


Figure 4. Grade distribution by semester for ESI4357.

The letter grade distribution for any of the last nine semesters can be viewed on the right along with the names of students who failed to pass the course (below C). The *Show Transcript* button links to the transcript of any student in the list.

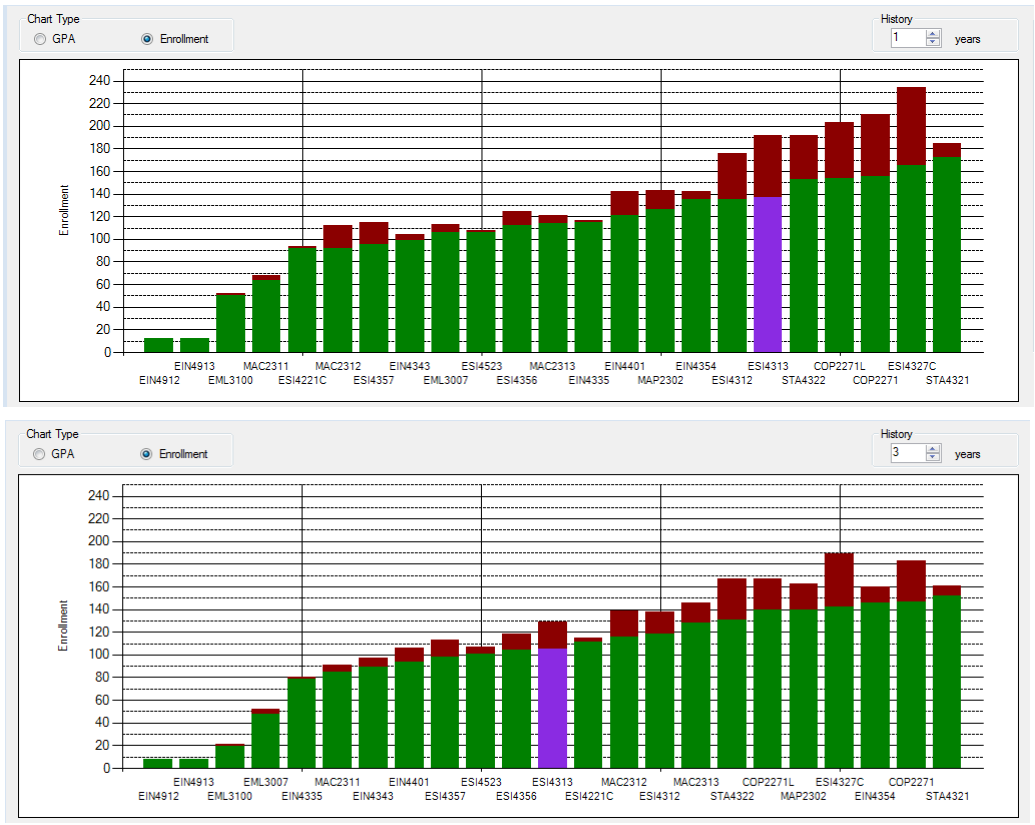


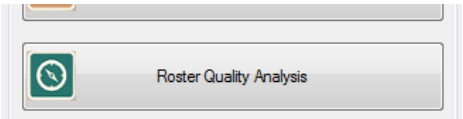
Figure 5. Course enrollment comparison (1 year vs last 3 years).

The same analysis can be performed on enrollment as well. The chart type option allows the user to switch to the enrollment view (figure 5). The bi-color enrollment chart shows the number of failing grades in red and the number of passing grades in green. Note that the courses are sorted by the number of passing students.

A useful feature of this chart is the ability to select the time frame. Course grade and enrollment averages can be displayed in one year, two year or three year time frames. Figure 5 compares one-year enrollment figures to three-year enrollment figures. The one-year enrollment averages are considerably higher than the three-year enrollment averages, indicating that the student population has been increasing.

Another advantage of this stacked chart format is that it also provides a perspective on how the fail rates have been changing over time for individual courses and in general. The comparison in figure 5 indicates that the fail rates have been increasing (taller red columns) which may be a consequence of increasing enrollment.

Roster Quality Analysis



This option helps the user to compare how the student quality varies in a given course over time.

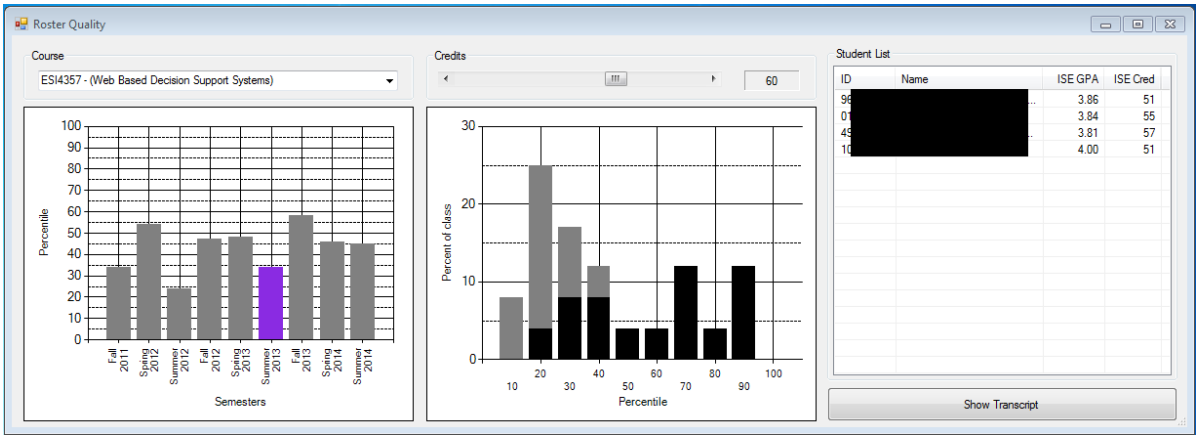


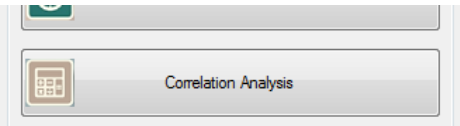
Figure 6. The class make-up for ESI4357 in summer 2013 and other semesters.

Previously, when discussing the variations in course grade averages from semester to semester, the possibility was brought up that this may be caused by variations in student quality. Specifically, it was found that grades in ESI4357 were consistently higher in the summer semester. The question whether this is caused by generous grading or a higher than usual student quality can be answered on this page.

The chart on the left displays the student quality for the selected course (ESI4357) in each of the last nine semesters. The student quality is expressed as the percentile of the average student taking the course in the semester. For example, in summer 2013 the average student in ESI4357 is at the 35th percentile of ISE students in terms of GPA, while in fall 2013, the average student is around the 60th percentile. This indicates that the weaker students (possibly those that fail the course in the first attempt) tend to take this course in the summer which makes the grading anomaly more serious. Even though the student quality is weaker in summer, the grades are higher which calls into question the grading standards in the summer section.

The second chart provides a detailed breakdown of student quality in the class for the selected semester (summer 2013). The distribution shows a large percentage of the class in the lower percentiles, which agrees with the rather low 35th percentile average. Any column on this chart can be clicked to obtain a list of students in that group. As before, the *Show Transcript* button links to the transcript of any student in the list.

Correlation Analysis



This option calculates the correlation between courses in the curriculum. It can also be used to study the accuracy of critical tracking courses in predicting the success of students later in upper division courses.

The critical tracking courses are early courses in curriculum hypothesized to be indicative of success, allowing at-risk students to be identified. Students are expected to complete the critical tracking sequence within the first 4-5 semesters of their studies. The critical tracking group for Industrial and Systems Engineering consists of MAC2311 (Calculus 1), MAC2312 (Calculus 2),

MAC2313 (Calculus 3), MAP2302 (Differential Equations), PHY2048 (Physics 1), PHY2049 (Physics 2) and COP2271 (Programming for Engineers).

This page consists of two sections. The top half charts the correlation values between the selected course and the rest of the required courses. Correlation values range from 1 to -1. A high correlation value (close to 1) indicates a strong correlation between two course grades (if a student does well in one course he/she will do well in the other) whereas a correlation value close to -1 indicates inverse correlation. A correlation value 0 means that there is no correlation.

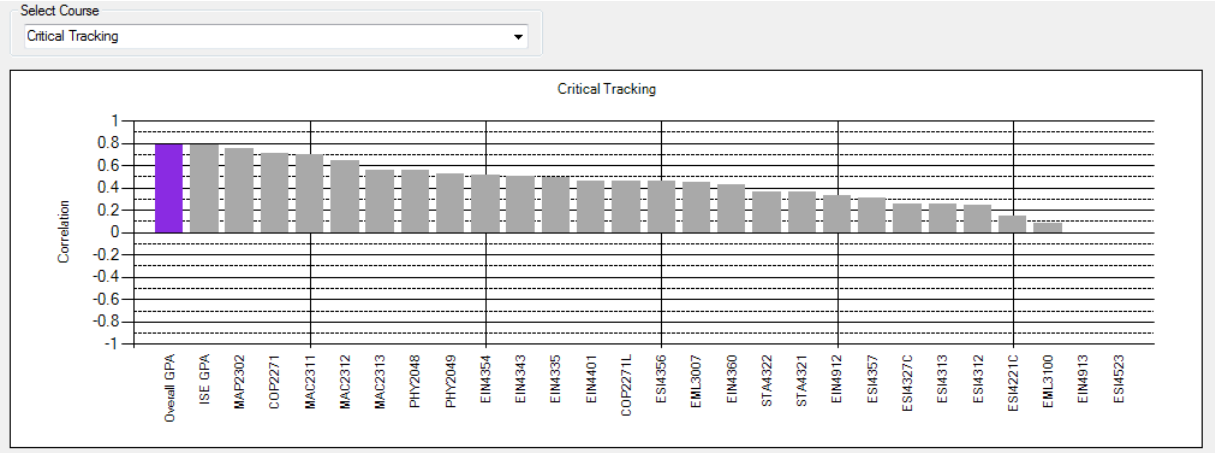


Figure 7. Correlation of course grades with the critical tracking group.

In Figure 7, the selected course is not an individual course but rather a course set, namely all courses in the critical tracking group. The highest correlations are to the overall GPA and to the ISE GPA, both around 0.8, indicating that the critical tracking GPA is indeed a good predictor of success in the ISE program. Not surprisingly, the next highest correlations are to the courses in the critical tracking course group (MAP2302, COP2271, MAC2311, etc.) themselves.

The bottom half of this page provides a more in-depth look into the relationship between the selected item in the dropdown list (critical tracking GPA in figure 8) and the selected item on the chart (overall GPA in figure 8).

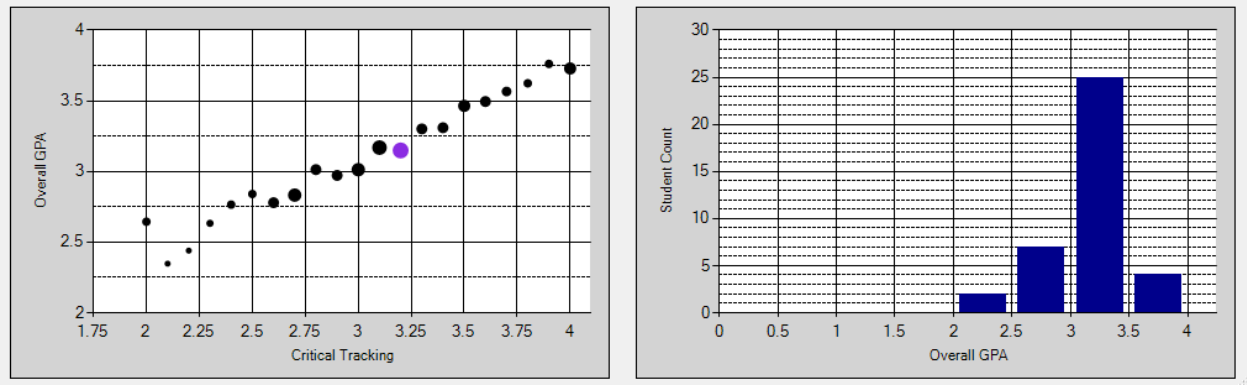
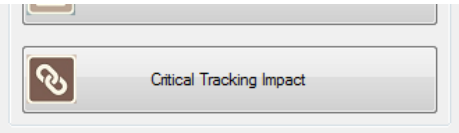


Figure 8. Relationship between critical tracking GPA and overall GPA.

The chart on the left shows an almost perfect linear relationship between critical tracking GPA and the overall GPA. Each data point (circular marker) on the chart represents a group of students whose critical tracking GPA are in the same range, while the size of the marker indicates the number of students in that group. According to this chart, students whose critical tracking GPA is between 3.1 and 3.2 (purple marker) have an average overall GPA of about 3.2.

Critical Tracking Impact



The primary focus of this option is to analyze the impact of changes to critical tracking requirements. Specifically, it enables the user to see the effects of increasing the minimum requirement (at least a grade of C) for passing the critical tracking courses on retention rate.

This page (shown in figure 9) is also divided into two sections. The interactive top half allows the user to create "What If" scenarios based on critical tracking minimum requirements. The bottom half contains two static charts that estimate the number of courses a student with a certain critical tracking GPA will repeat.

Figure 9. Impact of increasing the minimum passing grade for MAC2312 from C to C+.

Since the relationship between critical tracking courses and the overall and ISE GPA have been established, a topic of interest is whether to increase the minimum critical tracking requirements and how that would affect student performance. Similarly, it would be worthwhile to determine which courses are most sensitive to changes in minimum critical tracking requirements. On the top left corner, there is a list of critical tracking courses whose minimum pass threshold is

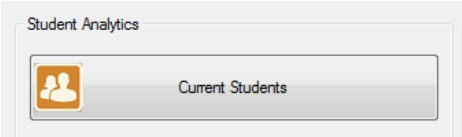
currently a grade of C. The user is allowed to increase this threshold for any course (MAC2312 in figure 9) and observe the impact on the rest of the curriculum. As a result of the increased minimum requirement, some of the current students (those who passed MAC2312 with a C) would not have been allowed into the department. The chart at the top analyzes their performance in other required courses.

The chart shows how many pass a course in the first attempt and how many others attempt the course multiple times. The courses with a long yellow/orange/red tail in the chart are the courses that would benefit from excluding these students because they would experience less attrition.

Figure 9 shows specifically the impact of increasing the pass requirement for MAC 2312 (Calculus 2). The analysis indicates that the biggest impact would be felt in COP2271 (Programming for Engineers), followed by ESI4327C (Matrix and Numerical Methods) and STA4322 (Introduction to Statistics Theory). Close to half of the students who passed MAC2312 with a C had trouble in gateway courses like COP2271 and ESI4327C, delaying their graduation significantly or even causing them to drop out. Since our department has a three-and-out rule in required courses, it is possible to estimate the number of students who would not have been dismissed from the department, improving the retention rate.

The static charts at the bottom simply relate the repeat percentage to the critical tracking GPA. As figure 9 clearly shows, the higher the critical tracking GPA is, the lower the repeat percentage. This shows that students with low critical tracking GPAs can create a rather large burden for the department by repeating courses at a high rate (as much as 25-45%).

Individual Student Performance



The *Current Students* option in Student Analytics allows access to undergraduate student academic records. As figure 10 shows, the list includes basic information about each students such as rank, ID, name, classification and GPA. This is a sortable list that can be ordered by any of the columns in either direction (low-to-high or high-to-low).

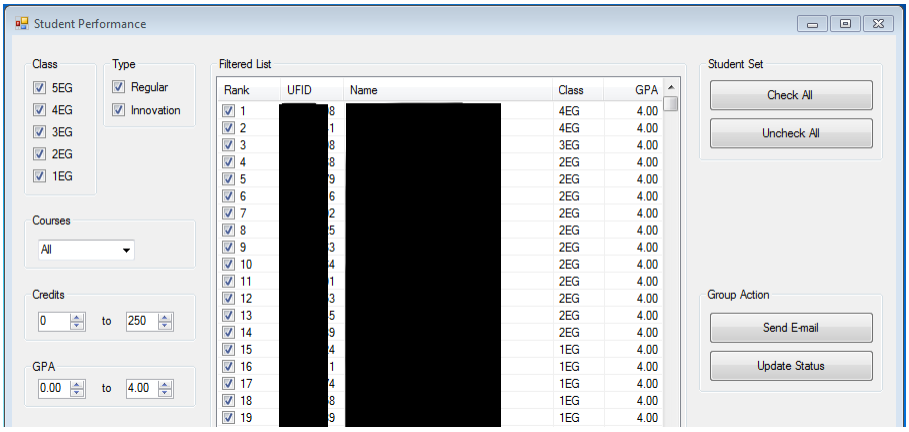


Figure 10. List of current undergraduates.

It is also possible to apply multiple filters (classification, type, GPA range, etc.) to generate a subset of students that satisfy the specified criteria. Figure 11 shows a filtered list that displays only students whose overall GPA (all courses) is less than 2.5 and whose credit hours are between 100 and 250, excluding 5EGs. This feature could be used to identify top students as well struggling students at various credit hour levels.

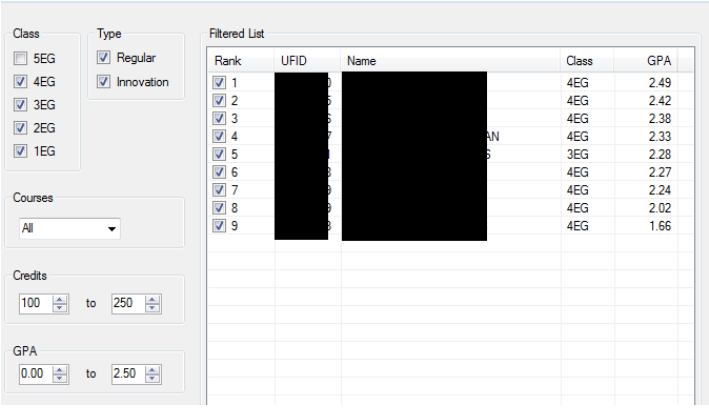


Figure 11. A filtered list of undergraduates.

A detailed analysis of any student's academic record can be performed by selecting that student and clicking the *Show Transcript* button (figure 12). This page is comprised of three sections: at the top-left, a navigation section in the form of a tree view, at the bottom-left, a data section that highlights important academic metrics and on the right, a panel that displays a list of courses.

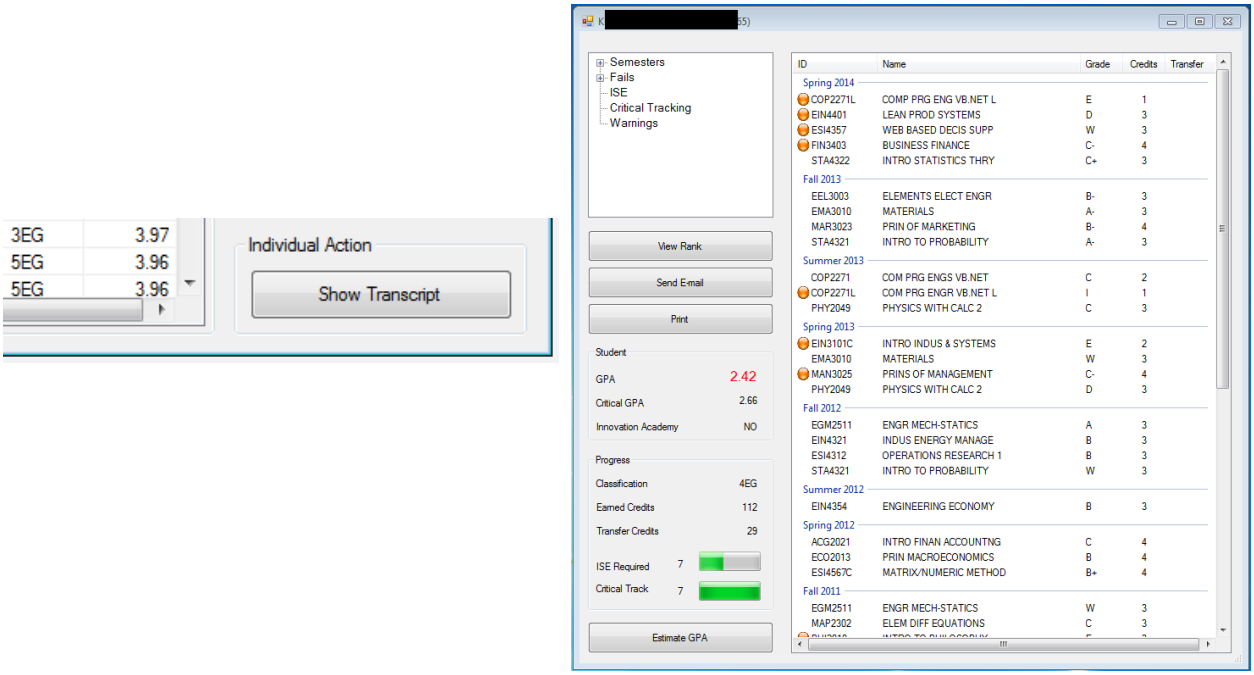


Figure 12. A student transcript.

Initially, the transcript is in *Semester* mode, displaying courses semester by semester (figure 13). In this mode, a colored dot to the left of a course indicates that it is an unresolved fail. Orange color means one or two failed attempts, whereas a red dot means three or more failed attempts.

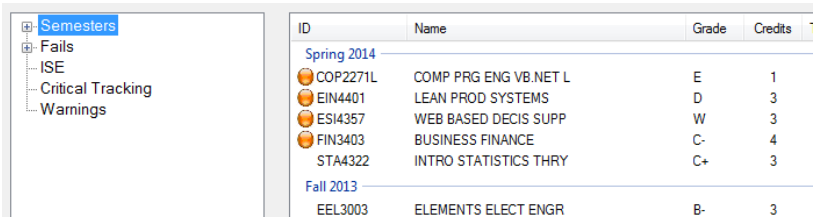


Figure 13. *Semester* view of a transcript

Using the tree view in the navigation panel the view mode can be switched to *Fails* or *Checklist* as well. In the *Fails* view, the course list contains all unsuccessful attempts for each unresolved course, whereas in the *Checklist* view it displays the status (passed, failed or not yet attempted) of courses in the curriculum. In the Checklist view, passed courses are marked with a green check and unresolved fails are marked with a red X. No mark indicates that the course has not been attempted yet. Figure 14 provides a sample of *Fails* and *Checklist* views.

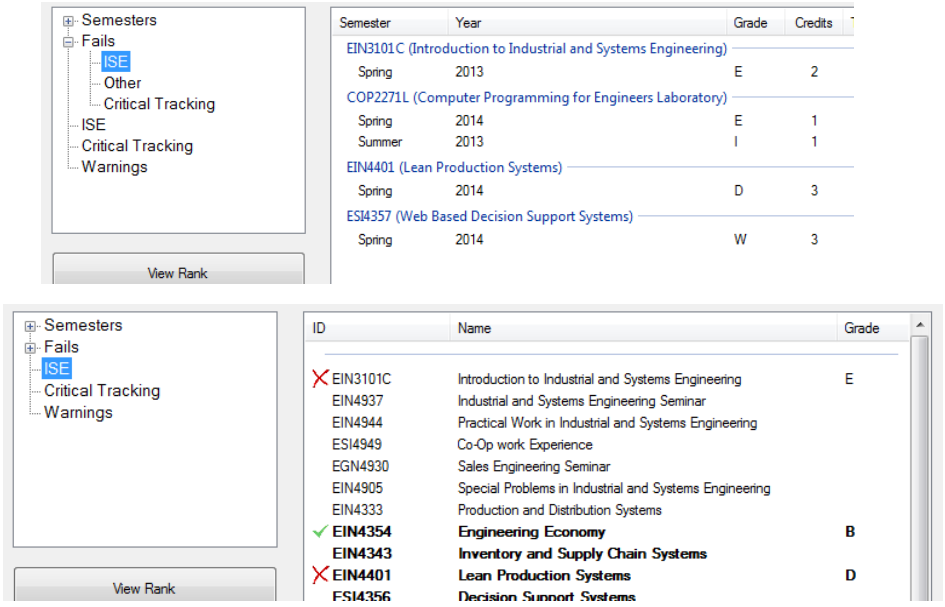


Figure 14. *Fails* (top) and *Checklist* (bottom) view of a transcript.

The ability to view the transcript of a student in different ways enables the user to assess the student's standing and progress in a short amount of time, without having to go through pages of courses. Although it is a rather simple and straight-forward tool, the authors find the transcript feature quite useful for basic advising needs.

An issue when evaluating a student's academic performance with respect to his/her peers, for instance when writing a recommendation letter, is to account for grade inflation in certain courses or by certain instructors. This may make it difficult to accurately determine how much value to assign to, say a B+ in a given course. Feedback received from faculty encouraged the development of a ranking tool that visually depicts the value of a student's grade in the semester it was received.

As shown in figure 15, this tool represents the grade this student received with a black band for each course. The relative position of the band and its thickness reveal the worth of this grade. A thin band with a low rank value (toward the top of the column) indicates that the student ranked at the top of the class along with a small number of students. Conversely, a band with a high rank value (toward the bottom of the column) indicates that the student is ranked low in his/her class.

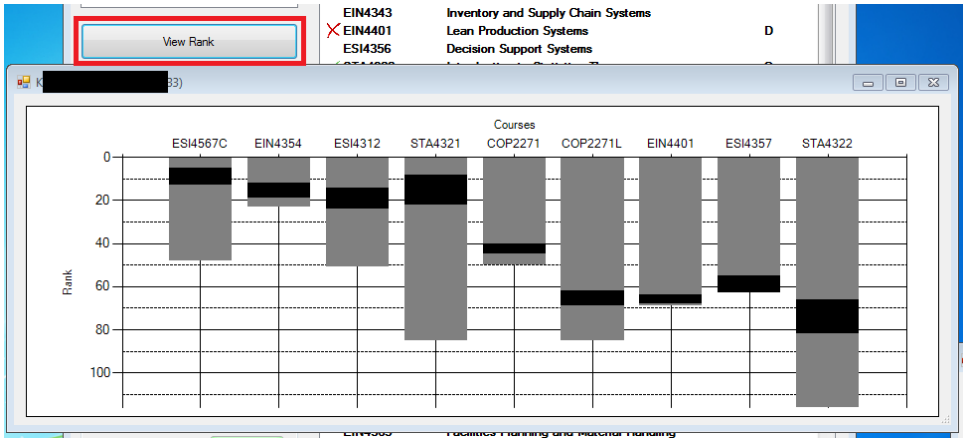
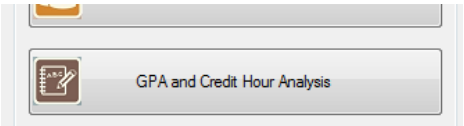


Figure 15. Visual depiction of a grade's worth in a course.

Courses with high grade inflation typically have a rather thick band of As and Bs that cover almost the entire spectrum. As a result, an A represented by a thick band that covers a large part of the column is not nearly as impressive and suggests that the high grade may be attributed to grade inflation and that the student did not really stand out among his/her classmates as his/her grade would imply. Therefore, this feature not only provides a better picture of a student's performance but it also reveals the courses where grade inflation may be an issue.

GPA and Credit Hour Analysis



This option is for the analysis of student GPA and credit hours. It enables the user to see the distribution of GPA and credit hours by classification.

Figures 16 and 17 shows both display modes controlled by the radio buttons on the top-left corner of the page. In the GPA mode (figure 16), the user is able to view and compare the GPA distributions for different student classifications (3EG, 4EG and 5EG). Students are classified according to number of credits completed. For example, students who have completed between 60 and 89 credits are classified as 3EG.

Undergraduate GPAs appear to be distributed normally with a mean around 3.1 to 3.2. It is possible to isolate a specific classification (right chart in figure 16) via the checkboxes. This reveals that 3EG GPAs (purple columns) are skewed to the high end, which is expected since 3EGs are just starting to take upper division courses.

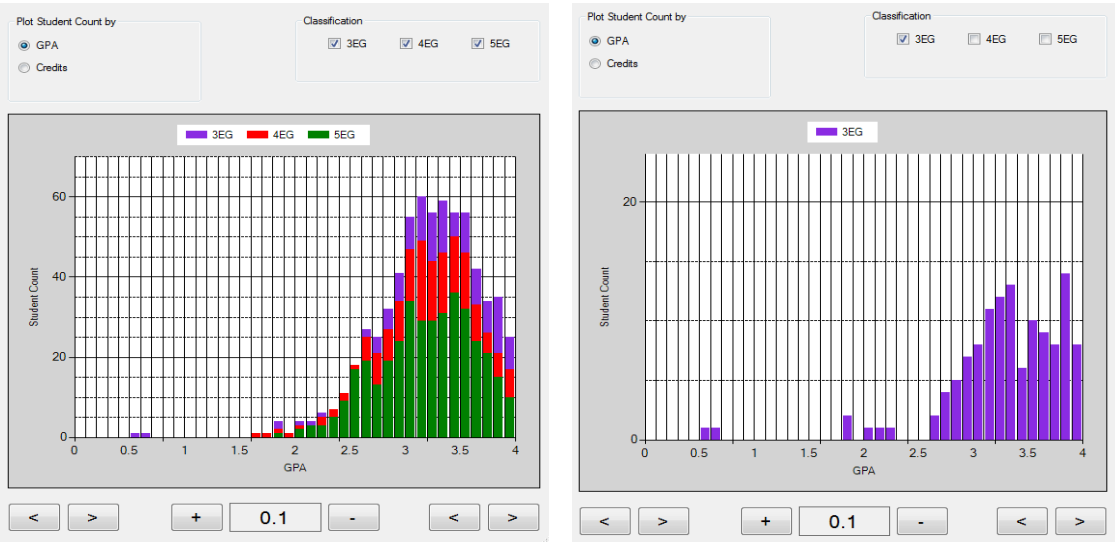


Figure 16. Distribution of undergraduate GPA by classification.

Switching to the credit hours view, the user can identify the students who have accumulated excessive hours and give them priority in advising. For example in figure 17, there are quite a few students over 160 credit hours which is significantly higher than the minimum 125 hours required for graduation. The list on the left displays students in the selected credit hour range. Consistent with the previous pages, The *Show Transcript* button links to the transcript of any student in the list. On either chart, the resolution and the display range can be adjusted via the controls below the chart.

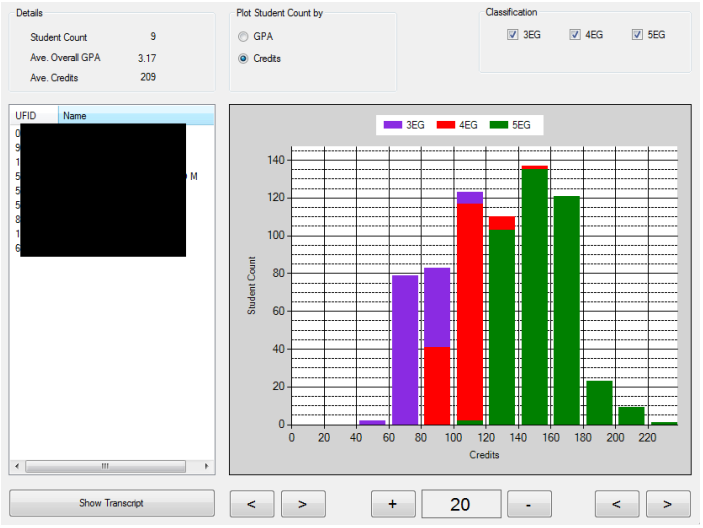
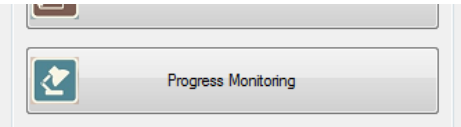


Figure 17. Distribution of undergraduate credit hours by classification.

Progress Monitoring



This option helps to identify students that are off-track. As discussed in the previous option, some students accumulate an excessive number of credits without making sufficient progress towards graduation. It is important to identify these students early and guide them in the right direction before they exhaust their options. For this purpose, the *Progress Monitor* option has been added to this application.

As shown in figure 18, this option allows the user to select a set of courses (milestones) and specify a minimum number of credit hours (threshold). It then provides a list of students who have not passed all of the milestone courses even though they have exceeded the credit hour threshold. This helps to identify students who are behind the curve in terms of progress and may need special attention.

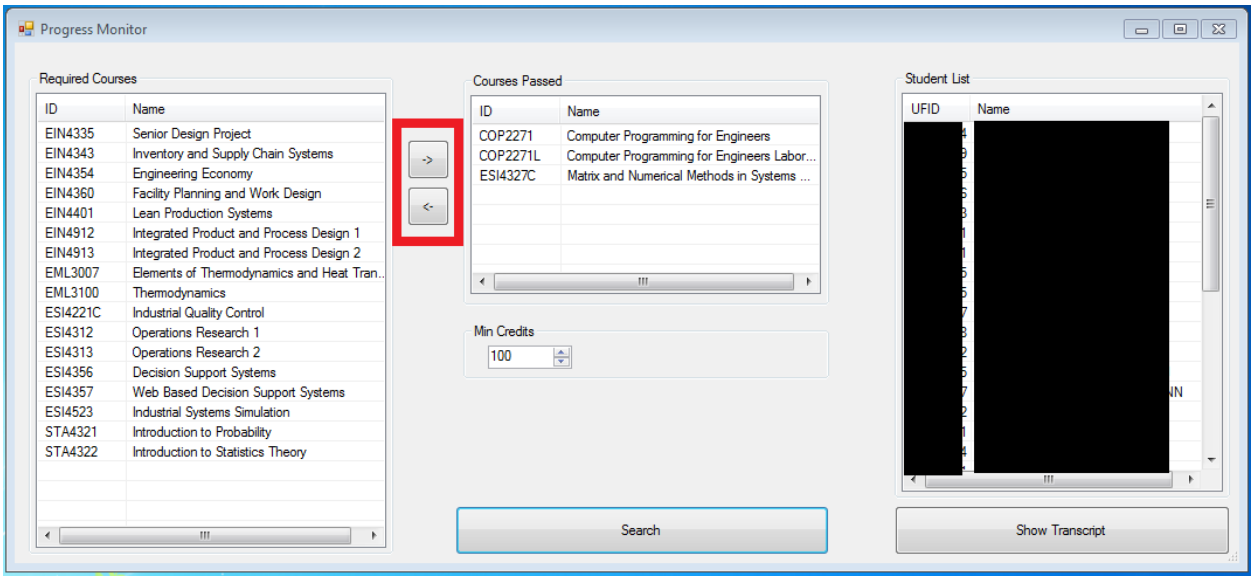
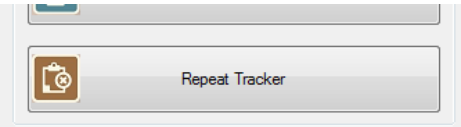


Figure 18. List of students who have not yet taken the gateway courses even though they have accumulated at least 100 credits.

Repeat Tracker



This option is there to help with the enforcement of a critical department rule. Specifically, it identifies students who are in danger of violating the three-and-out rule which states that a student must pass any required course with a C or better in at most three attempts. Students who have already failed a required course twice are contacted for advising while those who have failed three times are removed from the department.

This page performs a search for students who have repeated any course a specified number of times without passing it. The user selects the course from the drop down list, the number of fails in the radio button group and also specifies the preferred view, organizing the search results either by student or by course.

In the course view shown in figure 19, the search results list displays all students who have failed any ISE course twice without passing it ("unresolved fail"), organized by course. This view reveals which courses experience a high rate of unresolved fails and cause the most drop-outs. This information is especially useful when advising marginal students on course scheduling.

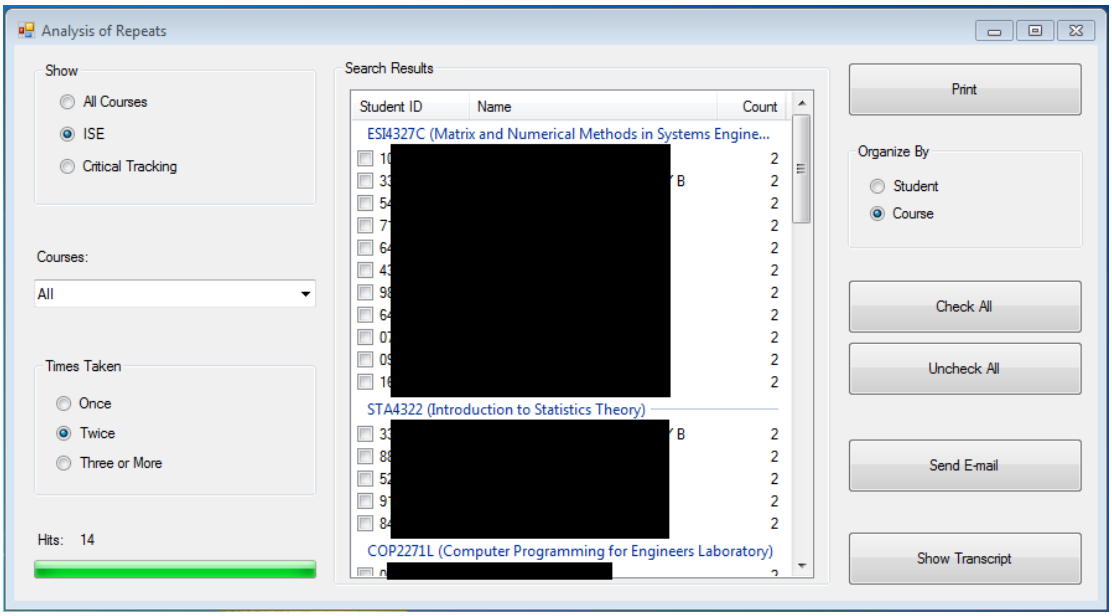


Figure 19. In course view, unresolved fails are organized by course.

Figure 20 shows the same results in the student view which displays the unresolved fails student by student. This view is useful in identifying problem students that need to be contacted for immediate advising.

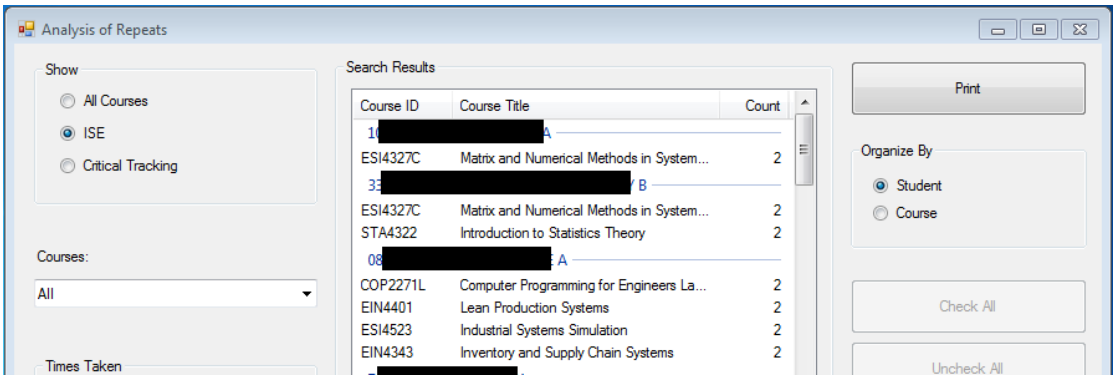


Figure 20. In student view, unresolved fails are organized by student.

Conclusions

This paper documents the development of a degree program management system which has proven useful for tracking and advising students based on actual grade data. Besides providing information on individual students, the system allows trends to be identified, such that student performance on seven critical tracking courses closely predicts eventual overall GPA.

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