Dalton State College

Detailed Assessment Report
2015-2016 MATH 3401

As of: 8/15/2016 10:01 AM EDT

(Includes those Action Plans with Budget Amounts marked *One-Time, Recurring, No Request.*)

Course Description

Theory and applications of matrix algebra, vector spaces, and linear transformations; topics include characteristic values, the spectral theorem, and orthogonality.

Program Outcomes

PO 1: Proof-Writing
To demonstrate an understanding of and ability to construct mathematical proofs

PO 2: Axioms
To demonstrate an understanding of and ability to work with axiomatic mathematical structures.

PO 3: Communicate Mathematics
To communicate using proper mathematical language and notation verbally, graphically and in writing.

PO 4: Proving Mathematical Properties
Use logical reasoning to prove mathematical properties

Outcomes, with Any Associations and Related Measures, Targets, Findings, and Action Plans

Outc. 1: Define Vector Spaces
Demonstrate understanding of the definition of vector spaces, subspaces, bases, and linear transformations.

Relevant Associations:

Standard Associations

SACSCOC 2012* Principles of Accreditation
3.3.1.1 educational programs, to include student learning outcomes
4.1 The institution evaluates success with respect to student achievement consistent with its mission. Criteria may include: enrollment data; retention, graduation, course completion, and job placement rates; state licensing examinations; student portfolios; or other means of demonstrating achievement of goals. (Student achievement)

General Education Goals Associations

2.2 Students will perform foundational mathematical operations and express and manipulate mathematical information or concepts in verbal, numeric, graphic, or symbolic forms while solving a variety of problems.

Institutional Mission Associations

2 Dalton State offers targeted bachelor's degrees, a full range of associate's degrees and career certificate programs, and a wide variety of public service activities.

Strategic Plan Associations

Dalton State College
3.1 Goal I: Renew excellence in undergraduate education to meet students' 21st century educational needs.

Related Measures

M 1: Exam question - vector spaces
Ask questions on an exam to determine student understanding of the definitions of vector spaces, subspaces, bases, and linear transformations.

Source of Evidence: Writing exam to assure certain proficiency level

Target:
Of the students that finish the course, at least 70% of students will demonstrate an understanding of vector spaces, subspaces, bases, or linear transformations.

Finding (2015-2016) - Target: Met
Spring 2016: 9 students were registered for Math 3401 and 8 students completed the course. To assess this objective, I used Question 5 on the Midterm Exam, which asked students to both determine a matrix for a linear transformation and to compute bases for the kernel and image of this transformation. Of the 8 students who completed the course, 7 of the students (87.5%) earned at least 75% of the points possible on that question and therefore demonstrated a solid understanding of the problem. This means that 1 student (12.5%) did not meet the target. This student did not successfully compute the bases for the image and the kernel of the transformation. All students, however, were able to successfully determine the matrix of the linear transformation.

Related Action Plans (by Established cycle, then alpha):

For full information, see the *Details of Action Plans* section of this report.

Emphasize definitions and understanding
Established in Cycle: 2015-2016
Spring 2016: 7 of the 8 students (87.5%) who completed this course successfully met the target of demonstrating an understanding...

Outc. 2: Compute Eigenvectors and Eigenvalues
Compute the characteristic polynomial, eigenvalues, and eigenvectors of matrices and linear operators.

Relevant Associations:

Standard Associations

SACSCOC 2012* Principles of Accreditation
3.3.1.1 educational programs, to include student learning outcomes
4.1 The institution evaluates success with respect to student achievement consistent with its mission. Criteria may include: enrollment data; retention, graduation, course completion, and job placement rates; state licensing examinations; student portfolios; or other means of demonstrating achievement of goals. (Student achievement)

General Education Goals Associations

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Related Measures

M 2: Exam question - eigenvectors
Ask questions on an exam to determine whether students can compute eigenvalue and eigenvectors of a given matrix or linear operator.

Source of Evidence: Writing exam to assure certain proficiency level

Target:
Of the students that finish the course, at least 70% of students will demonstrate an ability to compute eigenvalues and eigenvectors of a given matrix or operator.

Finding (2015-2016) - Target: Not Met
Spring 2016: 9 students were registered for Math 3401 and 8 students completed the course. To assess this objective, I used Question 3 on the Midterm Exam, which asked students to compute eigenvalues of a matrix and to determine bases for each associated eigenspace. Of the 8 students who completed the course, 5 of the students (62.5%) of the students earned at least 75% of the points possible on that question and therefore demonstrated a solid understanding of the problem. This means that 3 students (37.5%) did not meet the target. Students who did not meet the target had trouble computing the bases for the eigenspaces using the row reduction technique. Their errors were either arithmetic in doing the row reduction or were errors in interpreting the row-reduced echelon form into a basis. All students, however, did successfully compute the characteristic polynomial and eigenvalues of the matrix.

Related Action Plans (by Established cycle, then alpha):

For full information, see the *Details of Action Plans* section of this report.

More time on eigenvector computations early in semester
Established in Cycle: 2015-2016
Spring 2016: 5 of the 8 students (62.5%) who completed this course successfully met the target of computing eigenvalues and eige...

Outc. 3: Use Gram-Schmidt
Compute orthogonal or orthonormal bases using the Gram-Schmidt technique.

Relevant Associations:

Standard Associations

SACSCOC 2012* Principles of Accreditation
3.3.1.1 educational programs, to include student learning outcomes
4.1 The institution evaluates success with respect to student achievement consistent with its mission. Criteria may include: enrollment data; retention, graduation, course completion, and job placement rates; state licensing examinations; student portfolios; or other means of demonstrating achievement of goals. (Student achievement)

General Education Goals Associations

2.2 Students will perform foundational mathematical operations and express and manipulate mathematical information or concepts in verbal, numeric, graphic, or symbolic forms while solving a variety of problems.

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Related Measures

M 3: Exam question - orthonormal basis
Ask a question on an exam to determine if students can use the Gram-Schmidt process to compute an orthonormal basis for a given space.

Source of Evidence: Writing exam to assure certain proficiency level

Target:
Of the students that finish the course, at least 70% of students will demonstrate the ability to compute an

orthonormal basis using the Gram-Schmidt technique.

Finding (2015-2016) - Target: Met
Spring 2016: 9 students were registered for Math 3401 and 8 students completed the course. To assess this objective, I used Question 6 on the Midterm Exam, which asked students to compute an orthonormal basis using the Gram-Schmidt technique. Of the 8 students who completed the course, all 8 students (100%) met the target and successfully answered the question. This means that no students (0%) failed to meet the target. The midterm exam occurred shortly after we discussed the Gram-Schmidt process in class, so that probably helped let students remember and understand the process.

Related Action Plans (by Established cycle, then alpha):

For full information, see the *Details of Action Plans* section of this report.

Continue emphasis of Gram-Schmidt method
Established in Cycle: 2015-2016
Spring 2016: 8 of the 8 students (100%) who completed this course successfully met the target of computing an orthonormal basis ...

Outc. 4: Compute Systems of Equations Solutions

Compute solutions to consistent systems of linear equations using row reduction or use a least-squares approach to approximate solutions to inconsistent systems of linear equations.

Relevant Associations:

Standard Associations

SACSCOC 2012* Principles of Accreditation
3.3.1.1 educational programs, to include student learning outcomes
4.1 The institution evaluates success with respect to student achievement consistent with its mission. Criteria may include: enrollment data; retention, graduation, course completion, and job placement rates; state licensing examinations; student portfolios; or other means of demonstrating achievement of goals. (Student achievement)

General Education Goals Associations

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Related Measures

M 4: Exam question - system
Ask questions on an exam in order to determine whether students can solve a system of linear equations using row reduction and/or whether they can approximate a solution to an inconsistent system using a least-squares approach.

Source of Evidence: Writing exam to assure certain proficiency level

Target:
Of the students that finish the course, at least 70% of students will demonstrate an ability to either use row reduction to solve a system of linear equations or to use a least-squares approach to approximate the solution to an inconsistent system.

Finding (2015-2016) - Target: Met
Spring 2016: 9 students were registered for Math 3401 and 8 students completed the course. To assess this objective, I used Question 4 on the Midterm Exam, which asked students to compute a subspace of a vector space of all polynomials orthogonal to two given polynomials. In order to do this, students had to set up a system of linear equations from the orthogonality condition and then solve the system using row reduction. Of the 8 students who completed the course, 7 of the students (87.5%) sucessfully earned at least 75% of the points possible on the question, demonstrating a solid understanding of the question. This means that 1 student (12.5%) did not meet the target. The one student who did not meet the target managed to set up and solve the system successfuly, and only lost points in the final interpretation of the results. This means that all students demonstrated significant understanding in setting up and solving a system of linear equations.

Related Action Plans (by Established cycle, then alpha):

For full information, see the *Details of Action Plans* section of this report.

Continue emphasizing applications of systems and least-square methods
Established in Cycle: 2015-2016
Spring 2016: 7 of the 8 students (87.5%) who completed this course successfully met the target of computing solutions to linear ...

Outc. 5: Perform Matrix Algebra and Determinants Operations

Perform matrix algebra including matrix operations and computing inverses, as well as compute and interpret determinants of matrices.

Relevant Associations:

Standard Associations

SACSCOC 2012* Principles of Accreditation
3.3.1.1 educational programs, to include student learning outcomes
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General Education Goals Associations

2.2 Students will perform foundational mathematical operations and express and manipulate mathematical information or concepts in verbal, numeric, graphic, or symbolic forms while solving a variety of problems.

Institutional Mission Associations

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Strategic Plan Associations

Dalton State College

3.1 Goal I: Renew excellence in undergraduate education to meet students' 21st century educational needs.

Related Measures

M 5: Exam question - matrix algebra

Ask questions on an exam to determine whether students can perform matrix algebra, compute matrix inverse, and/or compute determinants.

Source of Evidence: Writing exam to assure certain proficiency level

Target:

Of the students that finish the course, at least 70% of students will demonstrate the ability to perform matrix algebra, to compute matrix inverse, and/or to compute and interpret determinants.

Finding (2015-2016) - Target: Met

Spring 2016: 9 students were registered for Math 3401 and 8 students completed the course. To assess this objective, I used Question 2 on the Final Exam, which asked students to approximate a solution of an inconsistent system of equations using a least-squares technique in order to make a population prediction. In order to do this, the normal equation of the inconsistent system much be computed, and this involves matrix multiplication and transposes. Of the 8 students that completed the course, 7 of the students (87.5%) successfully earned at least 75% of the points possible on that question. This means that 1 student (12.5%) did not meet the target. The one student who did not meet the target did manage to successfully perform matrix algebra in order to set up the normal system - he simply failed to finish the problem and left the interpretation and prediction step at the end out. This means that all students demonstrated significant understanding of matrix algebra and operations.

Related Action Plans (by Established cycle, then alpha):

For full information, see the *Details of Action Plans* section of this report.

Continue emphasis and applications of matrix algebra

Established in Cycle: 2015-2016

Spring 2016: 7 of the 8 students (87.5%) who completed this course successfully met the target of demonstrating an understanding...

Outc. 6: Unitarily Diagonalize Matrices

Apply the Spectral Theorem for Hermitian matrices and unitarily diagonalize such matrices.

Relevant Associations:

Standard Associations

SACSCOC 2012* Principles of Accreditation

3.3.1.1 educational programs, to include student learning outcomes

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General Education Goals Associations

2.2 Students will perform foundational mathematical operations and express and manipulate mathematical information or concepts in verbal, numeric, graphic, or symbolic forms while solving a variety of problems.

Institutional Mission Associations

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Strategic Plan Associations

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Related Measures

M 6: Exam question - diagonalize

Ask a question on an exam to determine whether a student can apply the Spectral Theorem and/or unitarily diagonalize a given matrix or operator.

Source of Evidence: Writing exam to assure certain proficiency level

Target:

Of the students that finish the course, at least 70% of students will demonstrate an understanding of the Spectral Theorem and be able to unitarily diagonalize a given matrix or operator.

Finding (2015-2016) - Target: Met

Spring 2016: 9 students were registered for Math 3401 and 8 students completed the course. To assess this objective, I used Question 3 on the Final Exam, which asked students to unitarily diagonalize a given matrix by finding both a diagonal matrix similar to the given matrix as well as the unitary matrix that does the diagonalizing. Of the 8 students who completed the course, all 8 students (100%) earned at least 75% of the points possible on that questions and thus demonstrated an understanding of the question. This means that 0 students (0%) did not meet the target. Students showed a strong understanding of how to find a unitary matrix that diagonalizes a given matrix, demonstrating the result of the Spectral Theorem.

Related Action Plans (by Established cycle, then alpha):

For full information, see the *Details of Action Plans* section of this report.

Continue emphasis of unitary diagonalization and include the most general form of the Spectral Theorem
Established in Cycle: 2015-2016
Spring 2016: 8 of the 8 students (100%) who completed this course successfully met the target of unitarily diagonalizing a given...

Outc. 7: Compute Canonical Forms and Decompositions
Compute canonical forms or decompositions of a matrix or linear operator, such as the Jordan Canonical Form or Singular Value Decomposition.

Relevant Associations:

Standard Associations

SACSCOC 2012* Principles of Accreditation
3.3.1.1 educational programs, to include student learning outcomes
4.1 The institution evaluates success with respect to student achievement consistent with its mission. Criteria may include: enrollment data; retention, graduation, course completion, and job placement rates; state licensing examinations; student portfolios; or other means of demonstrating achievement of goals. (Student achievement)

General Education Goals Associations

2.2 Students will perform foundational mathematical operations and express and manipulate mathematical information or concepts in verbal, numeric, graphic, or symbolic forms while solving a variety of problems.

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Related Measures

M 7: Exam question - canonical forms
Ask a question on an exam to determine whether students can compute a canonical form or decomposition of a given matrix, such as the Jordan Canonical Form or the Singular Value Decomposition.

Source of Evidence: Writing exam to assure certain proficiency level

Target:
Of the students that finish the course, at least 70% of students will be able to compute a canonical form or decomposition of a given matrix or operator, such as the Jordan Canonical Form or Singular Value Decomposition.

Finding (2015-2016) - Target: Met
Spring 2016: 9 students were registered for Math 3401 and 8 students completed the course. To assess this objective, I used Question 4 on the Final Exam, which asked students to compute the Jordan Canonical Form of a given matrix. Of the 8 students who completed the course, all 8 students (100%) were able to successfully compute the Jordan Canonical Form (JCF) of the given matrix in that problem. This means that 0 students (0%) did not meet the target. However, 2 students were not able to successfully produce the invertible matrix P made up of generalized eigenvectors that puts the matrix into JCF, showing that this was a weaker skill for the students other than simply computing the JCF.

Related Action Plans (by Established cycle, then alpha):

For full information, see the *Details of Action Plans* section of this report.

Devote more time to Jordan Canonical Form and contrast with other decompositions
Established in Cycle: 2015-2016
Spring 2016: 8 of the 8 students (100%) who completed this course successfully met the target of computing the Jordan Canonical ...

Details of Action Plans for This Cycle (by Established cycle, then alpha)

Continue emphasis and applications of matrix algebra
Spring 2016: 7 of the 8 students (87.5%) who completed this course successfully met the target of demonstrating an understanding of matrix algebra, matrix operations, and computing determinants, which means the target was met for this learning objective. This target was measured using a question on the Final Exam which asked students to best approximate a solution an inconsistent system of linear equations from data and use that approximation to make a future population prediction. In order to solve this problem, students had to compute both a matrix transpose and matrix multiplication, in addition to solving and interpreting the resulting system. All 8 students were able to perform the matrix operations required to set up the system, and the only student that did not adequately complete this problem forgot to finish the problem and make the predictions based on the result. Therefore in future semesters, I will continue to do as I did this semester and include applications of least-squares approximations in this course. I also plan to look for more interesting examples of least-squares approximations in science and engineering to increase student interest in the topic. In addition, no questions were asked on the final exam or midterm exam that tested student knowledge on computation of determinants. Since determinants are an important topic in linear algebra, I plan to incorporate such questions in future exams.

Established in Cycle: 2015-2016
Implementation Status: Planned
Priority: High

Relationships (Measure | Student Learning Outcome):
Measure: Exam question - matrix algebra | **Student Learning Outcome:** Perform Matrix Algebra and Determinants Operations

Continue emphasis of Gram-Schmidt method

Spring 2016: 8 of the 8 students (100%) who completed this course successfully met the target of computing an orthonormal basis for a given subspace using the Gram-Schmidt method, which means the target was met for this learning objective. This target was measured using a question on the Midterm Exam which asked students to use the Gram-Schmidt process to compute an orthonormal basis for a space with a given non-orthogonal basis. Since 100% of the students answered this question correctly on the midterm, my plan is to continue to emphasize the Gram-Schmidt process in this course. I also want to ensure that students understand the idea of orthogonality in a general vector space, so I will add questions to the midterm or final exams that ask students to interpret the concept of orthogonality. I also plan to raise the target on this objective to 80% in future semesters.

Established in Cycle: 2015-2016
Implementation Status: Planned
Priority: High

Relationships (Measure | Student Learning Outcome):
Measure: Exam question - orthonormal basis | **Student Learning Outcome:** Use Gram-Schmidt

Continue emphasis of unitary diagonalization and include the most general form of the Spectral Theorem

Spring 2016: 8 of the 8 students (100%) who completed this course successfully met the target of unitarily diagonalizing a given matrix, which means the target was met for this learning objective. This target was measured using a question on the Final Exam which asked students to both compute a diagonal matrix similar to the given matrix as well as a unitary matrix which does the diagonalization via similarity. All students in the course were able to successfully complete this problem. In future semesters, I plan to ask more questions on exams that will test students' knowledge of the Spectral Theorem. I also plan to discuss a more general version of the Spectral Theorem. This semester, the version I discussed only covered Hermitian matrices; I want to include all normal matrices in future semesters so students can see the most general version of this important result.

Established in Cycle: 2015-2016
Implementation Status: Planned
Priority: High

Relationships (Measure | Student Learning Outcome):
Measure: Exam question - diagonalize | **Student Learning Outcome:** Unitarily Diagonalize Matrices

Continue emphasizing applications of systems and least-square methods

Spring 2016: 7 of the 8 students (87.5%) who completed this course successfully met the target of computing solutions to linear systems of equations, which means the target was met for this learning objective. This target was measured using a question on the Midterm Exam which asked students to find a basis for a subspace of polynomials which met a certain orthogonality condition. This problem required students to set up a linear system equations, to solve that system, and to interpret their solution in the context of the subspace. This target was met, and in future semesters I will continue to discuss and include problems on exams which ask students not just to solve systems but to also apply these methods to other types of problems. In future semesters I will also assess how students approximated solutions to inconsistent linear systems using a least-squares approach and solving an associated normal equation.

Established in Cycle: 2015-2016
Implementation Status: Planned
Priority: High

Relationships (Measure | Student Learning Outcome):
Measure: Exam question - system | **Student Learning Outcome:** Compute Systems of Equations Solutions

Devote more time to Jordan Canonical Form and contrast with other decompositions

Spring 2016: 8 of the 8 students (100%) who completed this course successfully met the target of computing the Jordan Canonical Form (JCF) of a given matrix, which means the target was met for this learning objective. This target was measured using a question on the Final Exam which asked students to not only compute the JCF of a matrix but also to find an invertible matrix P which obtains the JCF from the matrix via similarity. While all students successfully obtained the JCF of the matrix, 2 of the students did not get the correct invertible matrix P. In the future, I will want to assess whether students can obtain this matrix in addition to the JCF. This method involves computing chains of generalized eigenvectors, and I plan to devote more time to this in the future so students get more practice. I also plan to include another decomposition, like the Singular Value Decomposition, into the course in the future so that students can contrast the JCF with these other decompositions. Due to the snow days we had this semester, we simply did not have enough time in the course to get to Singular Values.

Established in Cycle: 2015-2016
Implementation Status: Planned
Priority: High

Relationships (Measure | Student Learning Outcome):
Measure: Exam question - canonical forms | **Student Learning Outcome:** Compute Canonical Forms and Decompositions

Emphasize definitions and understanding

Spring 2016: 7 of the 8 students (87.5%) who completed this course successfully met the target of demonstrating an understanding of vector spaces, subspaces, bases, and linear transformations, which means the target was met for this learning objective. This target was measured using a question on the midterm exam which asked students to interpret a linear transformation as a matrix and to determine bases for the image and the kernel of this transformation. In future semesters, understanding the definitions of these fundamental structures in linear algebra must continue to be emphasized. For Spring 2016, I spent a significant amount of time at the beginning of the semester reviewing these ideas from Math 2256 and I believe that helped students get a good handle on the rest of the content. In future semesters, I would continue to do this in order to best prepare students for the more complicated content of this course.

Established in Cycle: 2015-2016
Implementation Status: Planned
Priority: High

Relationships (Measure | Student Learning Outcome):
Measure: Exam question - vector spaces | **Student Learning Outcome:** Define Vector Spaces

More time on eigenvector computations early in semester

Spring 2016: 5 of the 8 students (62.5%) who completed this course successfully met the target of computing eigenvalues and eigenvectors of a given matrix, which means the target of 70% was not met for this learning objective. This target was measured using a question on the Midterm Exam which asked students to compute the eigenvalues of a matrix and to give a basis of eigenvectors for the corresponding eigenspaces. In future semesters, I hope more than 70% of students will meet this target. In order to do this, I would suggest spending more time at the beginning of the course on how to compute eigenvalues and eigenvectors, especially on how to determine a basis for each associated eigenspace. While students in Spring 2016 were able to compute the eigenvalues, they had some arithmetic errors in the computation of the bases using row reduction and had some misinterpretations of the reduced echelon form. To improve this, I would spend extra time on this topic and make sure that it is assessed earlier in the semester, before a midterm exam. For example, including more homework problems on the subject would help students get more practice with this fundamental concept. I also plan to routinely assess student understanding of this process as the semester progresses, since eigenvalues and generalized eigenvectors play a critical role later topics.

Established in Cycle: 2015-2016
Implementation Status: Planned
Priority: High

Relationships (Measure | Student Learning Outcome):
Measure: Exam question - eigenvectors | **Student Learning Outcome:** Compute Eigenvectors and Eigenvalues

Analysis Questions and Analysis Answers

What strengths and weaknesses did your assessment results show? In addition, please describe 2 to 3 significant improvements or continuous improvement measures you'll put in place as a result of your assessment findings.

Based on the fact that 6 of the 7 assessed targets were met, this course seems to be in a strong position. Students had a strong grasp of the computational aspects of advanced linear algebra, including matrix algebra, row reduction, eigenvalue/eigenvector computations, and computing canonical forms and diagonal forms. The only weakness seems to be that early in the semester, students strugggled a bit with eigenvector and eigenspace computations. However, since later topics included these computations as well, it seems that students eventually grasped these techniques as the later targets were all met. This possibly shows that repeatedly involving eigenvalue/eigenvector computations in the course and in various applications helps students to master the concepts. To improve this course, I would suggest an earlier and stronger emphasis of eigenvalue and eigenvector/eigenspace computations, and I would suggest more assessment of the fundamental non-computational concepts of linear algebra, such as inner product spaces & orthogonality, and similarity & bases. It is more difficult to assess understanding of concepts without direct computations involved, so better measures for the course will have to be implemented in future exams.