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Improving Disciplinary Literacy in an Electronics course

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Abstract – **Electronics (EMT1255) is a required course for the Associate Degree in Applied Science (AAS) in Electromechanical Engineering Technology (EMT) at New York City College of Technology. EMT1255 introduces semiconductor devices and their applications in electronic-circuits. Students are expected to understand the structures and principles of semi-conductor devices and the configuration and principles of basic electronic circuits. They also learn to analyze and design electronic circuits. In the lab setting, they acquire troubleshooting knowledge and hands-on technical skills. In this reading intensive course, students need to read the lab manual and a textbook of over 700 pages. Therefore, reading and understanding the textbook is a main concern., Given the breadth and depth of materials covered in the course, instructors often struggle with teaching specialized concepts, formula, and technical terminologies, because of the lack of strategies to engage students in active reading and learning.**

In this paper, the challenges students face in reading to learn in EMT 1255 and the strategies used to overcome these challenges will be discussed. First, we will review the correlation between students' reading proficiency and their performance in the course by analyzing the results of reading assessments administered in three sections (N=66) of EMT1255 from Fall 2015 to Fall 2016. This will allow us to identify the impact of students' reading skills on their ability to learn in EMT1255. Secondly, we will look at how students' learning habits affect their performance in the course by examining the student survey results based on the ABET assessment outcomes of the course.

We will also describe the Reading Effectively Across the Disciplines (READ) program, a college-wide initiative established in 2013 to train faculty to implement instructional strategies and develop assignments to facilitate reading to learn across the disciplines. In this program, EMT and reading faculty work together to improve students' disciplinary literacy.

Index Terms – College reading, Electronics course, ABET student outcomes, disciplinary literacy

INTRODUCTION

We are living in a remarkable era with human knowledge multiplying in an accelerated rate [1]. To meet the 21st Century workplace demands, employers are looking for candidates who are not only equipped with technical skills and knowledge, but also other competencies, including effective communication, teamwork, and problem-solving skills. Therefore, college engineering programs must seek and develop new initiatives to meet these challenges.

Content knowledge alone does not prepare students sufficiently for the disciplinary literacy they need to be successful in their careers. Disciplinary literacy is significant because it is the "specialized knowledge and abilities possessed by those who create, communicate, and use knowledge" within a specific discipline [2]. In Engineering courses, this refers to training students to think, communicate, represent, and apply content knowledge like expert engineers. As described in the ABET competencies, this literacy is translated into a range of skills and practices that reflect the current requirements in the engineering field.

At New York City College of Technology (NYCCT), Electromechanical courses primarily equip students with technical knowledge and skills in lecture and lab settings. In addition to these traditional teaching and learning settings, we perceive a need to enhance students' disciplinary literacy by engaging them in the reading-to-learn process. To do so, we implemented READ (Reading Effectively Across the Disciplines) in the Electronics course (EMT 1255) to help students acquire more in-depth understanding of content knowledge, engage in disciplinary thinking to analyze, evaluate, and apply knowledge and skills through active reading and learning.

METHODOLOGY

1. Reading assessment

In the Fall semester of 2016, Electronics (EMT1255) was selected to be part of the Reading effectively Across the Disciplines (READ) program, and 3 sections of students participated in this initiative. EMT1255 is a 4 credit theory/lab course specifically structured to meet the goals mentioned, since it provides students the basic foundation principles to pursue other required courses, such as electrical networks, digital systems and control systems.

EMT1255 also affords students the opportunity to integrate and apply knowledge from prerequisite courses in math, physics and circuit analysis to solving technical problems within the course.

As part of the READ team, faculty members teaching EMT1255 were carefully trained to develop reading strategies to meet the goals of the READ program. These strategies and assignments were used to enhance students' disciplinary literacy through reading-to-lean. In addition, with the help of the READ administrator, the faculty developed initial and final READ assessments to assess students' competencies in comprehension, analysis, application, and evaluation of content knowledge. These assessments were administered during the 2016 academic year.

The assignments consisted of reading materials and carefully constructed theory and lab questions which mapped the course outcomes to an assessment rubric developed by the READ program administrator, as presented in [3, Tab. 1].

2. ABET assessment

As college educational demands are constantly changing, ABET, the Accreditation Board of Engineering Technology, has been tasked in finding a new set of guidelines to assess engineering technology programs in the US. The result was a new set of standards known as TCK 2000, which later became the standard assessment benchmark for engineering technology programs [4]. In particular, Criterion III, student outcomes listed 11 skills (*a-k*) that engineering programs must address in order to achieve accreditation.

EMT 1255, a course within the EMT AAS program, has targeted 6 of 11 Students Outcomes of Criterion III. The EMT department at NYCCT chooses 6 Student Outcomes *a, b, d, e, g,* and *k* as the targeted outcomes for EMT1255(see Table 2).

Table 1. READ Assessment Rubric

Performance Criteria	Full Proficiency 4	Adequate proficiency 3	Approaching proficiency 2	Low proficiency 1
Comprehension	Understands the main idea and major details in the text and is able to make logical inferences.	Understands most of the information in the text and is able to make some logical inferences.	Understands some ideas in the text and struggles to make logical inferences.	Unable to understand the main points of the text and make logical inferences.
Analysis	Able to identify text structure, fully understand and analyze the relationships among ideas, and interpret information presented in diverse formats and media.	Able to identify text structure, understand and analyze some of the relationships among ideas, and interpret some information presented in diverse formats and media.	Has some difficulties in identifying text structure, understand and analyze the relationships among ideas, and interpret information presented in diverse formats and media.	Unable to identify text structure, understand and analyze the relationships among ideas, and interpret information presented in diverse formats and media.
Context	Able to use concepts and ideas in the text to solve problems proficiently or make connection/apply them to a new context accurately and in a meaningful and relevant way.	Able to use concepts and ideas in the text to solve problems or make connection/ apply them to a new context accurately, but has some limitations.	Able to use some concepts and ideas in the text to solve problems partially or make connection/ apply them in a new context with minor mismatching of information and limitations.	Unable to use concepts and ideas in the text to solve problems or make connection/apply them in a new context.
Evaluation	Identifies purpose and evaluates the argument and specific claims in a text with adequate support, including valid reasoning, relevant and sufficient evidence.	Identifies purpose and evaluates the argument and specific claims in a text with some support, including valid reasoning, relevant and sufficient evidence.	Identifies purpose and evaluates the argument and specific claims in a text but with limited or no support, including the valid reasoning, relevant sufficient evidence.	Unable to identify purpose and evaluate the argument and specific claims in a text, including valid reasoning, relevant and sufficient evidence.

Source: "READ Assessment Rubric," *Reading Effectively Across the Disciplines (READ)City Tech OpenLab* by J. C. But. Copyright 2015-2017. Reproduced with permission and retrieved from https://openlab.citytech.cuny.edu/readinitiative/

Table 2. 2016-2017 ETAC/ABET Criterion 3 Student Outcomes Addressed in EMT 1255

a.	an ability to apply knowledge of mathematics, science, and engineering
b.	an ability to design and conduct experiments, as well as to analyze and interpret data
c.	an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d.	an ability to function on multidisciplinary teams
e.	an ability to identify, formulate, and solve engineering problems
f.	an understanding of professional and ethical responsibility
g.	an ability to communicate effectively
h.	the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i.	a recognition of the need for, and an ability to engage in life-long learning
j.	a knowledge of contemporary issues
k.	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Source: *ABET Accreditation*, 2016-2017. Retrieved from www.abet.org

RESULTS

1. Reading assessment

Students were assessed in four Performance Criteria (comprehension, analysis, context, and evaluation), and student responses were scored on a scale of 1to 4 (see Table 1). The range of scores represents the highest proficiency (4) to the lowest (4). The results of the Spring 2016 semester are presented below. Altogether 54 students in the three sections of EMT1255 responded. The mean rubric score (MRS) based on the two assessments was 2.69, corresponding to a mean arithmetic score (MAS) of 76.79%. A further assessment of the final reading assessment revealed the following (see Table 3 for Performance Criteria):

Table 3. Reading Assessment Outcomes

Performance Criteria	Mean Rubric Score (M.R.S.)	Mean Arithmetic Score (M.A.C.)
Comprehension	3.44	89.49%
Analysis	2.33	75.63%
Context	2.33	70.87%
Evaluation	1.83	66%
• The mean arithmetic score was 75.76% in the 3 classes.		
• The mean rubric score was 2.57 in the 3 classes.		

From Table 3, it can be concluded that students scored above average on comprehension questions, satisfactory on "Analysis," and "Context" questions, and unsatisfactory on "evaluation" questions. The results showed that students had little difficulty in understanding the concept and principles presented in the text/course. However, students were not as proficient in analyzing relationship among ideas, concepts, and components and applying concept and ideas to solve problems and connecting content knowledge to a new context. The area that students struggled the most is "Evaluation." They found it challenging to draw conclusion, make judgment, and predict results based on evidence and valid reasoning.

2. ABET assessment

In spring 2016, 54 students in three sections of the EMT program took EMT 1255, and participated in the READ program. At the end of the semester, 51 students were surveyed to determine, if the ABET student outcomes *a, b, d, e, g*, and *k* were achieved. Table 4 summarizes their responses.

Table 4. ABET Survey Student Outcomes

Student Outcomes from Criterion 3	(1)	(2)
a. an ability to apply knowledge of mathematics, science, and engineering;	82%	18%
b. an ability to design and conduct experiments, as well as to analyze and interpret data;	76%	24%
d. an ability to function on multidisciplinary teams;	77%	23%
e. an ability to identify, formulate, and solve engineering problems;	86%	14%
g. an ability to communicate effectively;	75%	25%
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	86%	14%

(1): percentage of students who reported that the outcomes were met in EMT1255.
(2): percentage of students who reported that the outcomes were NOT met in EMT1255.

Overall, students responded favorably to the survey of student outcomes, compiling a favorable mean average of 80.57%. A high percentage (82% to 86%) of students felt confident in meeting the ABET Criterion 3 student outcomes, especially *a, b, e,* and *k*. Overall, students perceived themselves as competent in applying knowledge and technical skills to engage in engineering activities, analyze and solve engineering problems. At the same time, around 25% of the students felt less prepared in conducting, analyzing, and interpreting experiments, serving effectively in a technical team, and applying communication in diverse forms in technical and non-technical settings.

DISCUSSION

A study showed that when asked to rank the ABET performance outcomes, graduates of 11 engineering majors consider teamwork, communication, data analysis, and problem solving as more significant than other criteria [5]. This also asserted that the engineering industry, which once emphasized mainly on employees' technical skills, nowadays places equal importance on their communication and interpersonal skills. Our ABET survey outcomes showed that more students in EMT1255 felt proficient in applying knowledge, analyzing and solving problems than in communication skills and teamwork.

While the survey responses contained students' self-reported outcomes, the reading assessment results showed their performance outcomes. The survey results correlated with the READ assessment results in a number of ways. As

students expressed confidence in analysis and application of content knowledge in engineering technology, they would have attained prior understanding of concepts, principles, and skills in their discipline. This was reflected in the high average score (3.44 out of 4) on "comprehension" in the reading assessment. The average scores on "analysis," and "context," were the same (2.33 out of 4), and the average score on "evaluation" was the lowest (1.83 out of 4) among all categories. Students were somewhat competent in analyzing relationship among ideas, and interpreting information presented in diverse formats and media. They also showed reasonable competency in applying concepts and ideas in the text to solve problems. However, they generally lacked proficiency in critical reasoning and making valid judgment and prediction based on relevant evidence.

Considering all sets of outcomes and results, it can be concluded that students in EMT1255 were relatively more proficient in technical skills than in communication and critical reasoning skills. Along with communication and critical reasoning skills, another area that needs improvement is their ability to function effectively in a technical team. These skills are all parts of the disciplinary literacy that is required for a successful career in the engineering industry.

In order to create a coherent set of assessment criteria that specifically catering to Engineering courses, the READ program team also developed an ABET assessment rubric (See Table 5) by mapping four ABET outcomes to the READ program outcomes. This rubric provides an integrated assessment tool to monitor ABET as well as READ program outcomes in future assessments of READ program students. The EMT 1255 faculty plan to use this rubric for the Fall 2017 semester.

CONCLUSION

Disciplinary literacy in today's engineering industry is more broadly defined then having sufficient technical knowledge and skills. It is instead a way of thinking, speaking, and functioning in a dynamic environment where ideas, technologies, knowledge and team players at various levels converge and are actively engaged with one another. To improve specific areas of disciplinary literacy among our students, we plan to implement formative assessments and strategies that better address their academic needs as well as sufficiently prepare them for a successful engineering career.

In the READ program, the implementation of an integrative rubric (Table 5) that maps key elements of the ABET and READ rubric is an important step to assess students' disciplinary literacy. This will allow us to assess their technical knowledge, analytical skills, ability to apply content knowledge and technical skills to solve problems, and ability to use critical reasoning to evaluate activities and problems, select appropriate solutions, and predict results. Among others, we plan to combine cooperative learning with active reading strategies to enhance students' interest and ability to engage in reading-to-learn. These strategies can also serve as tools to improve students' communication and teamwork competency outside the lab setting. We will also design assignments that encourage inquisitive learning. This can be done as post-reading or post-lecture activities to enhance students' metacognitive skills by asking them to generate questions about what they learn in text and understand how they approach the body of knowledge they acquire in both lecture and lab.

As the demands in the engineering field are evolving, so are the pedagogical approaches in engineering courses. What we plan to do in EMT 1255 is a response to the changes of the industry and the needs to prepare our students to meet the challenges that come with these changes.

Students in the READ gain confidence motivation and knowledge by participating in READ learning activities that improve their overall critical thinking and integrative learning experience in the Electromechanical Engineering Technology program. Many EMT1255 students who participated in READ expressed satisfaction, and motivation to complete their studies, and go on to pursue a Bachelor of Technology degree.

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TABLE 5. Integrated ABET-READ Assessment Rubric

Performance Criteria	Full Proficiency 4	Adequate proficiency 3	Approaching proficiency 2	Low proficiency 1
a. an ability to apply knowledge of mathematics, science, and engineering; **ABET Outcome (*a*) maps to Comprehension of the READ rubric.**	Understands the main ideas and major details of written and graphical data from the text and is able to make logical inferences.	Understands most of the information in the text and is able to make some logical inferences.	Understands some ideas in the text and struggles to make logical inferences.	Unable to understand the main points of the text and make logical inferences.
b. an ability to design and conduct experiments, as well as to analyze and interpret data; **ABET Outcome (*b*) maps to Analysis of the READ rubric.**	Understands and analyzes relationships among ideas, and interpret information in diverse formats and media.	Understands and analyzes some of the relationships among ideas, and interprets information in diverse formats and media.	Has difficulties in identifying relationships among ideas, and interpreting information in diverse formats and media.	Unable to identify and analyze the relationships between ideas, and interpret information in diverse formats and media.
e. an ability to identify, formulate, and solve engineering problems; **ABET Outcome (*e*) maps to Context of the READ rubric.**	Able to identify and use all of the concepts and ideas from the text to solve problems proficiently having several unknowns.	Able to identify and use most concepts and ideas from the text to solve problems having several unknowns.	Struggles to identify concepts and ideas from the text to solve problems, needed to solve basic problems.	Unable to identify concepts and ideas from the text, needed to solve problems.
3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions * **ABET Outcome (*3*) maps to Evaluation of the READ rubric.**	Able to apply and integrate a knowledge of math, science, technology to evaluate and/or solve engineering technology problems. Responses show critical reasoning and relevance.	Able to apply and integrate most knowledge of math, science, technology in evaluating and/or solving engineering technology problems. Responses are relevant, but not complete.	Has some difficulties integrating a knowledge of math, science and technology in evaluating and/or solving engineering problems. Responses lack critical reasoning and relevance.	Unable to integrate a knowledge of math, science and technology, to evaluate and/or solve engineering technology problems. Responses lack critical reasoning and relevance.

* Outcome (3) is among the proposed changes under Criterion 3 as approved by the ABET Board of Delegates and the Engineering Area Delegation on October 16/17, 2015, for a one-year first reading review and comment period.