

Critical Thinking Skills in Non-Calculus Ready First Year Engineering Students

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A. Honors 2014 King Fahd University of Petroleum and Minerals Merit Scholarship for Graduates 2007 Agip-Texaco Scholarships for Nigerian Undergraduates

B. Publications

1. S. M. Shakil Hussain, Mustapha Alao Animashaun, Muhammad Shahzad Kamal, Nisar Ullah, Ibnelwaleed A. Hussein, Abdullah S. Sultan (2016). Synthesis, Characterization and Surface Properties of Amidosulfobetaine Surfactants bearing odd-number hydrophobic tail, Journal of Surfactant and Detergents: doi: 10.1007/s11743-016-1788-9
2. Sultan, A.S., Animashaun, M., Hussein, I. A. (2015). Influence of Nanoadditives on the Thermal and Rheological Properties of Viscoelastic Surfactants Used in Matrix Acidizing, presented at 2015 AIChE Annual Meeting in Salt Lake City, Utah, USA. November 8-13.

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Melissa Morris is currently a Teaching Associate Professor for the Freshman Engineering Program, in the Benjamin M. Statler College of Engineering and Mineral Resources at West Virginia University (WVU). She graduated Summa cum Laude with a BSME in 2006, earned a MSME in 2008, and completed her doctorate in mechanical engineering in 2011, all from WVU. At WVU, she has previously served as the Undergraduate and Outreach Advisor for the Mechanical and Aerospace Engineering department and the Assistant Director of the Center for Building Energy Efficiency. She has previously taught courses such as Thermodynamics, Thermal Fluids Laboratory, and Guided Missiles Systems, as well as serving

as a Senior Design Project Advisor for Mechanical Engineering Students. Her research interests include energy and thermodynamic related topics. Since 2007 she has been actively involved in recruiting and outreach for the Statler College, as part of this involvement Dr. Morris frequently makes presentations to groups of K-12 students, as well as perspective WVU students and their families.

Dr. Morris was selected as a Statler College Outstanding Teacher for 2012, the WVU Honors College John R. Williams Outstanding Teacher for 2012, and the 2012 Statler College Teacher of the Year.

Critical Thinking Skills in First Year Non-Calculus Ready Students

Introduction

Critical thinking is defined as self-reflective thinking[1]. Critical thinking requires the use of certain skills and disposition to evaluate thoughts and ideas with the purpose of refining them [2, 3]. Critical thinking involves an in depth evaluation of events, problems, ideas, and artifacts before accepting or framing a conclusion or opinion [4]. Engineers are trained to become problem solvers and critical thinking is essential for problem solving. Many educators believe that critical thinking skills are important and should be promoted in schools and universities, but they feel unequipped to teach those skills[5, 6].

The purpose of this study is to evaluate the critical thinking skills of students that begin in engineering with deficiencies in mathematical knowledge. These students tend to struggle in college and their retention in engineering is low (less than 40% retention rate).

The goals of the study are to: a) identify areas of weaknesses in students' critical thinking skills, and b) evaluate the relationship between critical thinking scores and students' cumulative grade point average (cGPA). Specifically, our interest is to determine if students with high critical thinking scores perform better in their first semester in college. This study answers the question: Are critical thinking skills a predictor of students' success in their first semester in college?

Methodology

Characteristics of the Participants: This study was conducted at West Virginia University, a large land grant institution in the Mid-Atlantic region. Seventy-seven (77) students, mostly male, participated in the study. Table 1 summarizes the characteristics of the participants in this study. At the time of the study, all students were enrolled in their first semester at the academic institution and were enrolled in College Algebra.

Table 1. Characteristics of the Participants

Characteristics		Parameter
Gender Distribution	Sample Size (n)	77
	% Female	17 (n=13)
	% Male	83 (n=64)
High School GPA		3.57±0.40*

*Represented as mean ± standard deviation

Critical Thinking Assessment: The Tennessee Tech Critical Thinking Assessment (CAT) test was used to evaluate students' critical thinking skills during their first semester in college[7, 8]. As indicated in Table 2, the CAT test consists of 15 open ended questions that measures students' ability, to use and apply relevant information to evaluate a problem, to provide alternative explanations for a pattern of results, identify additional information needed to

evaluate a hypothesis, and to identify and explain the best solution to a problem, among other skills.

Table 2. Skills evaluated using the CAT Test [9]

Critical Thinking Skills Assessed
Summarize the pattern of results in a graph without making inappropriate inferences
Evaluate how strongly correlational-type data supports a hypothesis
Provide alternative explanations for a pattern of results that has many possible causes
Identify additional information needed to evaluate a hypothesis
Evaluate whether spurious information strongly supports a hypothesis
Determine whether an invited reference is supported by specific information
Provide relevant alternative interpretations for a specific set of results
Separate relevant from irrelevant information when solving a real-world problem
Use and apply relevant information to evaluate a problem
Use basic mathematical skills to help solve a real-world problem
Identify suitable solutions for a real-world problem using relevant information
Identify and explain the best solution for a real-world problem using relevant information
Explain how changes in a real-world problem situation might affect the solution

Cumulative GPA (cGPA): Students' cumulative grade point average (GPA) was assessed at the end of the first semester using institutional information. This project was reviewed and approved by the West Virginia University Institutional Review Board (IRB).

Analysis of Data: A linear regression model was used to evaluate the relationship between CAT scores and cumulative GPA. Significance was considered using a p-value less than 0.05.

Results

Critical Thinking Skills: The average CAT scores obtained for the students tested was 17.8 ± 5.8 (mean \pm standard deviation). These scores were slightly higher than the scores obtained for freshman students at a different institution [8].

Tables 3 and 4 summarizes the results from the Critical Thinking Assessment (CAT) test. The results obtained were compared to the national averages for CAT scores, shown in the fifth column of Tables 3 and 4. According to Table 3, the students scored above the national average for skills such as the ability to evaluate whether spurious information strongly supports a hypothesis, the ability to use basic math skills to solve a problem, and the ability to separate relevant and non-relevant information in a problem.

Table 3. Thinking skills mastered by students

Critical Thinking Skills Measured in the CAT Test	Maximum Points per Question	Points Obtained by Students (Mean±stdev)	% Attainable*	Mean for National Average
Evaluate whether spurious information strongly supports a hypothesis	1	0.75±0.44	75.00	0.52
Separate relevant from irrelevant information when solving a real-world problem	4	3.16±1.13	79.00	3.01
Use basic mathematical skills to help solve a real-world problem	1	0.83±0.38	83.00	0.75

*% Attainable = points obtained divided by the maximum number of points

As shown in Table 4, students enrolled in College Algebra appears to have problems summarizing patterns of results without making inappropriate inferences, identifying information needed to evaluate a hypothesis, providing alternative interpretation to results, and evaluating how correlational-type data supports a hypothesis.

Table 4. Thinking skills underdeveloped in students

Critical Thinking Skills Measured in the CAT Test	Maximum Points per Question	Points Obtained by Students (Mean±stdev)	% Attainable*	Mean for National Average
Summarize the pattern of results in a graph without making inappropriate inferences	1	0.35±0.48	35	0.58
Evaluate how strongly correlational-type data supports a hypothesis	3	0.45±0.81	15	0.69
Identify additional information needed to evaluate a hypothesis	4	0.30±0.57	7.6	0.96
Provide relevant alternative interpretations for a specific set of results	2	0.24±0.57	12	0.57

*% Attainable = points obtained divided by the maximum number of points

For the students enrolled in the study, the average cumulative GPA (cGPA) at the end of the first semester was 3.22 ± 0.56 . Figure 1 illustrates the relationship between students' CAT scores and their first semester cGPA. As shown in Figure 1, students' GPA at the end of the first semester in college was related to the CAT scores. A linear regression model showed that students with high CAT scores seemed to perform better in college and obtained a higher GPA at the end of the first semester ($p\text{-value} < 0.05$).

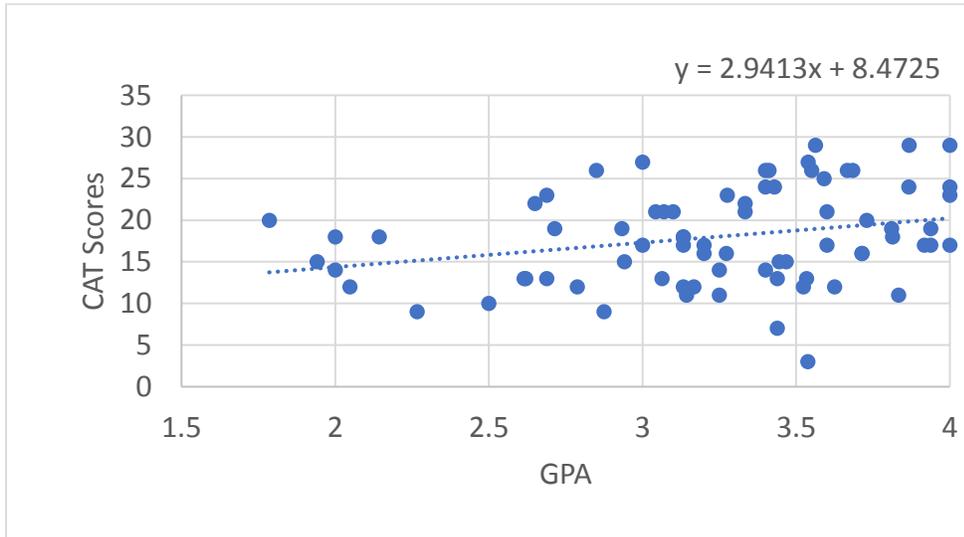


Figure 1. Relationship between CAT scores and cumulative GPA (cGPA) at the end of the first semester in College. A linear regression model was used to understand the relationship between CAT scores and first semester cGPA ($p\text{-value} < 0.05$).

Discussion

Critical thinking skills are essential for the solution of problems in engineering. In this study, strengths and weaknesses in critical thinking skills were identified in students enrolled in College Algebra during their first semester in a pre-engineering program. In the study, students showed deficiencies in summarizing patterns of results without making inappropriate inferences, identifying information needed to evaluate a hypothesis, providing alternative interpretation to results, and evaluating how correlational-type data supports a hypothesis. These deficiencies must be addressed before students move to upper level engineering courses.

In this study, first semester cGPA was found to be related to students' CAT scores. In general, students with higher CAT scores performed better at the end of their first semester in college.

Conclusion

Although this study found a relation between CAT scores and first semester cumulative GPA, the investigators recognize that critical thinking skills, although important, are not the only determinants of students' success in college. Other factors such as students' self-efficacy and their motivation play a role in students' academic performance and success in college.

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