Tolerance of ambiguity: A comparison between engineering and non-engineering students

Abstract
The typical student mind-set is focused on getting the 'right' answer for a problem with certainty that every problem has one and only one correct answer. However, this viewpoint is not consistent with real life problems as the information available for solving a real-life problem can be stochastic and incomplete. As a result, many correct answers could be possible and the acceptable one would depend on several factors. Students must therefore be exposed to such ambiguous problem spaces. This paper presents a comparison of undergraduate students' tolerance of ambiguity. The modified Rydell-Rosen Ambiguity Tolerance scale was administered to a cross-section of students to measure their responses. Differences between engineering and non-engineering students were observed. The influence of academic classification and gender were also observed.

Introduction

The typical learning environment in general emphasizes "correct" answers and provides a problem space with full information to solve a problem. Thus, students get anxious when they encounter a situation with information or data that is irrelevant to the solution or does not have "one" answer. There has been a concerted effort to move from a structured to an ill-structured (or open-ended) problem space to provide more realistic learning experiences. Complete information is seldom available in real-life problems and hence present challenges to individuals whose problem-solving experience has been limited to complete information. This situation is further complicated if the "incomplete information" also includes unknown relationships between the various variables. The incompleteness of information may be statistical in nature and thus an uncertainty associated with it. The nuance between uncertainty and ambiguity has been articulated by Schrader, Riggs, and Smith [1]. They note that while uncertainty is the lack of information, ambiguity is the lack of knowledge about relationships between the various variables.

Formally introduced by Frenkel-Brunswick [2] as a behavioral trait, tolerance of ambiguity has also been reported as a situational response [3]. Tolerance of ambiguity has been defined by Budner [4] as "the tendency to perceive ambiguous situations as desirable" while intolerance of ambiguity as "the tendency to perceive ambiguous situations as sources of threat". The positive aspects associated with tolerance of ambiguity include creativity and critical thinking [5] – [9]. Tatzel [10] noted the correlation between tolerance of ambiguity and several academic success traits. Intolerance of ambiguity may result in avoidance behaviors which can impact academic performance. The influence of tolerance of ambiguity has been investigated in various areas such as mathematics education [11] engineering education [12], [13], and medical education [14], [15]. It is also reported in the literature [16] that tolerance of ambiguity was correlated with the personality trait of extroversion.

This paper provides an insight into the tolerance of ambiguity in undergraduate students at an HBCU. The study includes a comparison between engineering and non-engineering students and the effect of gender and classification.

Method

Participants: The participants were undergraduate students enrolled at an HBCU. The sample was a cross-section of engineering and non-engineering majors with academic standing ranging from freshmen to graduating seniors. A total of 405 participants responded to the survey. The details of the participant demographics are given in Table I. The study had the approval of the IRB.

Table I: Participant demographics

	Engineering (N = 216)		Non-engineering (N = 189)	
	Female (F)	Male (M)	Female (F)	Male (M)
Freshman (Total = 187)	33	103	44	7
Sophomore (Total = 69)	6	23	31	9
Junior (Total = 67+1*)	3	20	39	5
Senior (Total = 80+1*)	5	23	45	7
Total (403+ 2*)	47	169	159	28

*One junior and one senior preferred not to provide the gender.

Materials: The tolerance to ambiguity was measured using the modified Rydell-Rosen Ambiguity Tolerance (AT-20) scale [17]. The AT-20 consists of 20 true and false items with a reliability of 0.86. A 'correct' response indicates "tolerance for ambiguity". The AT-20 relates the performance in a complex task, dogmatism, and rigidity. The AT-20 (Appendix A) was administered as an online fillable form.

Results and Discussion

The first comparison was done between all the engineering (ENG) and all the non-engineering (Non ENG) students. The percentage (%) of correct answers for each of the 20 questions of the AT-20 are shown in Fig. 1. The average percentage score for engineering students was 45% and for the non-engineering students was 41%. The difference between the two groups was statistically not significant ($p<0.05$). Of the 20 questions on the survey, a higher percentage of engineering students than non-engineering students got 12 questions correct. Only 7 out of 20 questions were answered correctly by more than 50% engineering students and 50% or more non-engineering students responded correctly to only 6 of the 20 questions. Statistically significant differences ($p < 0.05$) were observed between engineering and non-engineering students on Q#1, Q#2, Q#4, Q#6, Q#7, Q#8, Q#10, Q#12, Q#19. Of these questions with statistically significant differences, a higher percentage of engineering students responding correctly to Q#1, Q#2, Q#4, Q#6 and Q#7. Interestingly, questions Q#2 and Q#6 pertain to ambiguous social interactions which were correctly answered by more than 50% of the engineering students while less than 40% non-engineering students answered these questions correctly. And, a higher percentage of the non-engineering students responded correctly to questions Q#8, Q#10, Q#19 of which two questions (Q#8, Q#10) pertain to social interactions.

The highest percentage of correct answers by the engineering students was for Q#1 which indicated they were not deterred by a problem which may not have a solution. The highest percentage of non-engineering students correctly answered Q#19 which pertained to "fooling" around with new ideas. The lowest percentage of correct answers for engineering students was for Q#20 which indicated an attraction towards perfect balance. The lowest percent of correct answers for non-engineering students was for Q#7, pointing to the expectation of a solution to every problem. The engineering students has the next lowest correct percentage of answers for Q#7, while the non-engineering had almost the same percentage of correct answers for Q#20 as Q#7, showing consistency in both the groups attraction to situation with low ambiguity. The next lowest percentage of correct answers for both groups was for Q#16 which indicated that a large percentage of the students derived satisfaction from completing a jigsaw puzzle pointing to an attraction towards problems with solutions. However, for all the three questions Q#7, Q#16, Q#20, the percentage of correct answers for engineering students was higher than non-engineering students.

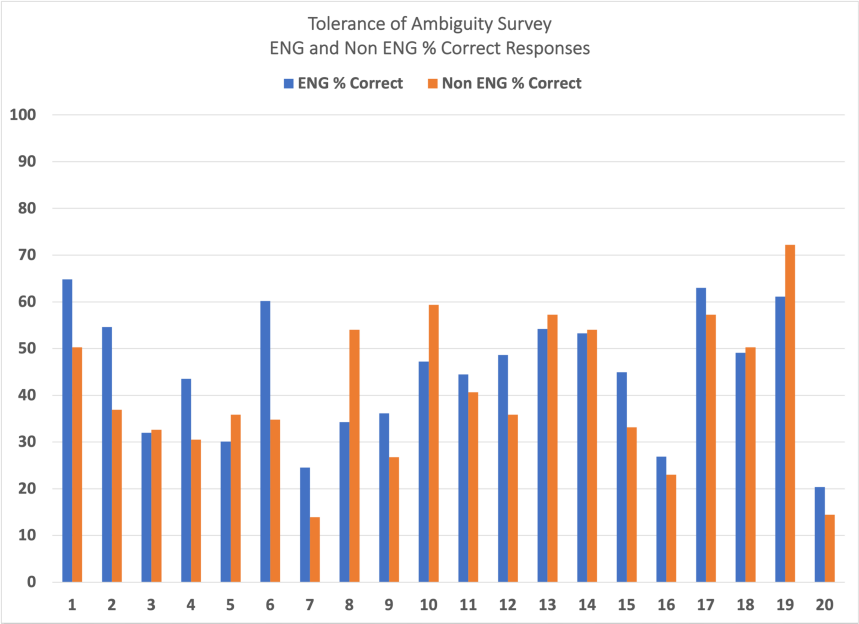

Figure 1: Comparison of engineering and non-engineering students

The impact of duration of stay in college on the responses of the engineering students to the AT-20 survey was analyzed. The data was grouped as under classmen (freshmen and sophomores – lower level) and upper classmen (junior and seniors – upper level). The average score for the under classmen was 45% and for the upper classmen was 45% as well. These average scores suggest that duration of stay in college had little impact on the tolerance of ambiguity of engineering students. In 10 of the 20 questions under classmen had a higher % of correct

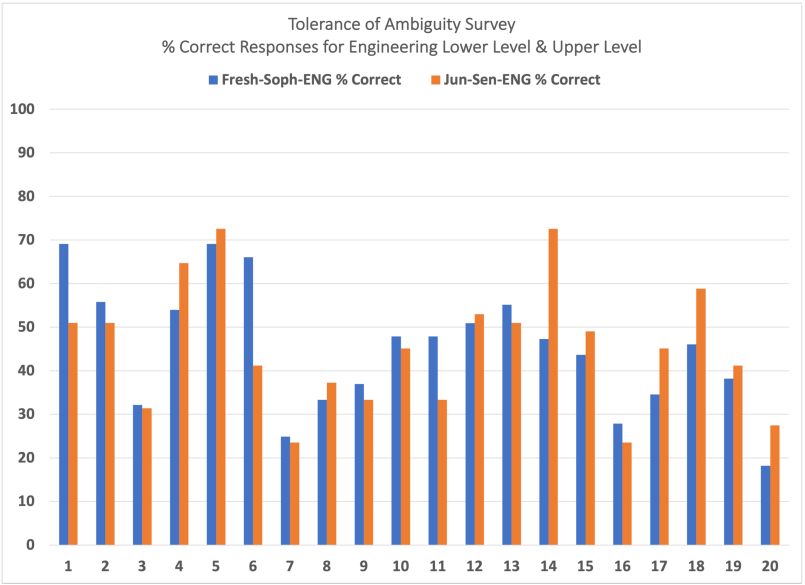

Figure 2: Impact of duration of stay in college - engineering students

answers. The % correct answers to each question are given in Fig. 2. There were no statistical differences between under and upper classmen in the % correct responses to the various questions except for Q#1, Q#4, Q#6, Q#11, Q#14, Q#17, and Q#18. Of these questions, the under classmen had higher % correct answers to Q#1, Q#6, and Q#11. This indicated that the under classmen were more open to tackling problems even if a solution was not obvious. They were also more comfortable in a socially ambiguous situation. The upper classmen had higher % correct answers to Q#4, Q#14, Q#17, Q#18 which showed their recognition that problems with ambiguous answers can exist (Q#18). They also exhibited higher risk-taking characteristics (Q#4, Q#14, Q#17).

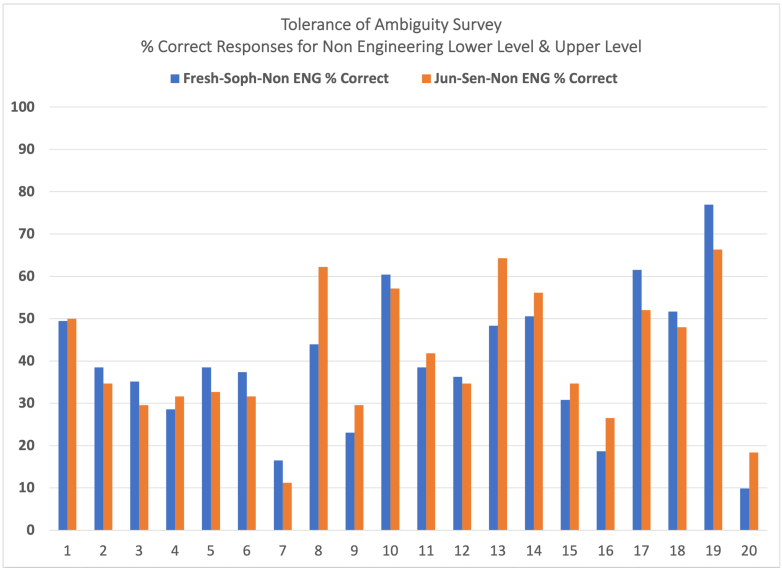

Figure 3: Impact of duration of stay in college - non-engineering students

The impact of duration of stay on the tolerance of ambiguity of non-engineering is shown in Fig. 3. The average score of the under classmen was 40% and of the upper classmen was 41%. Interestingly, the under classmen had a higher % of correct answers to 10 out of the 20 questions. The under classmen had a score of 50% or higher on only four questions (Q#10, Q#17, Q#18, and Q#19). The highest % correct answers (77%) were for Q#19 which related to experimenting with new ideas. The highest correct % answers for the upper classmen also were for Q#19, however, the percentage was lower than the under classman. The lowest percentage of correct responses by the under classmen was to the statement of perfect balance being essential (Q#20). The lowest % of correct responses by the upper classmen were to the statement that every problem has a solution (Q#7) indicating a preference for unambiguous problems.

A comparison between the responses to the 20 questions of the survey of engineering and non-engineering students was made as a function of duration of stay in college (Figs. 4, 5). The engineering under classmen had an average correct score of 45% while the non-engineering under classmen had an average score of 40%. The engineering upper classmen had an average correct score of 45% while the non-engineering classmen had an average correct score of 41%. The differences between groups were statistically not significant ($p < 0.05$). A higher % of the engineering under classmen had correct answers to 13 questions as compared to the non-engineering under classman (7 questions) (Fig. 4).

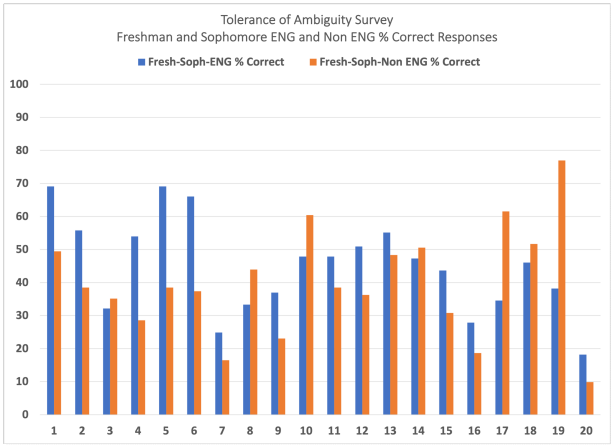

Figure 4: Under classmen comparison

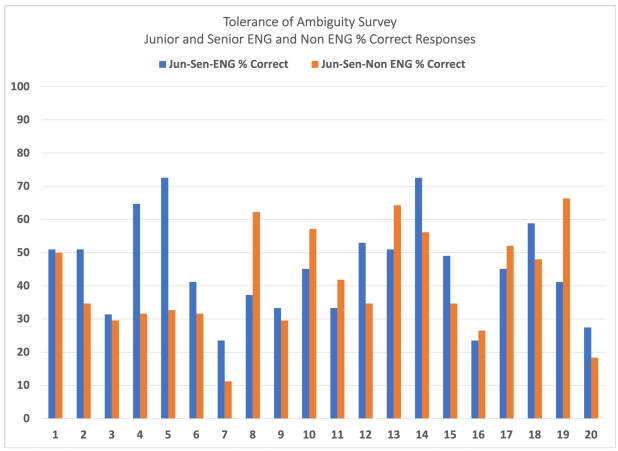

Figure 5: Upper classmen comparison

A higher % of the engineering upper classmen also had answers to 13 questions as compared to non-engineering upper classmen, of which 11 questions were the same as the under classmen (Fig. 5).

The mediating effect of gender on tolerance of ambiguity is shown in Fig. 6 which is a comparison between male engineering and female non-engineering students. It was noted that the female respondents were very consistent in the % correct responses (~50%) to the questions of AT-20 survey. The male respondents on contrary had a large variation (21% - 67%, average of 45%) in the % correct answers to the questions on the survey. The lowest % correct responses of the male engineering students were pertaining to perfect balance being essential (Q#20) while the highest % correct responses were to the statement of asserting independence (Q#17).

Conclusions and Future Work

The tolerance of ambiguity of undergraduate students at an HBCU was measured by the modified Rydell-Rosen AT 20 questionnaire. It was noted that the engineering students had a higher score average on the survey as compared to the non-engineering students. Both the engineering under classmen and upper classmen had higher average scores than their non-engineering

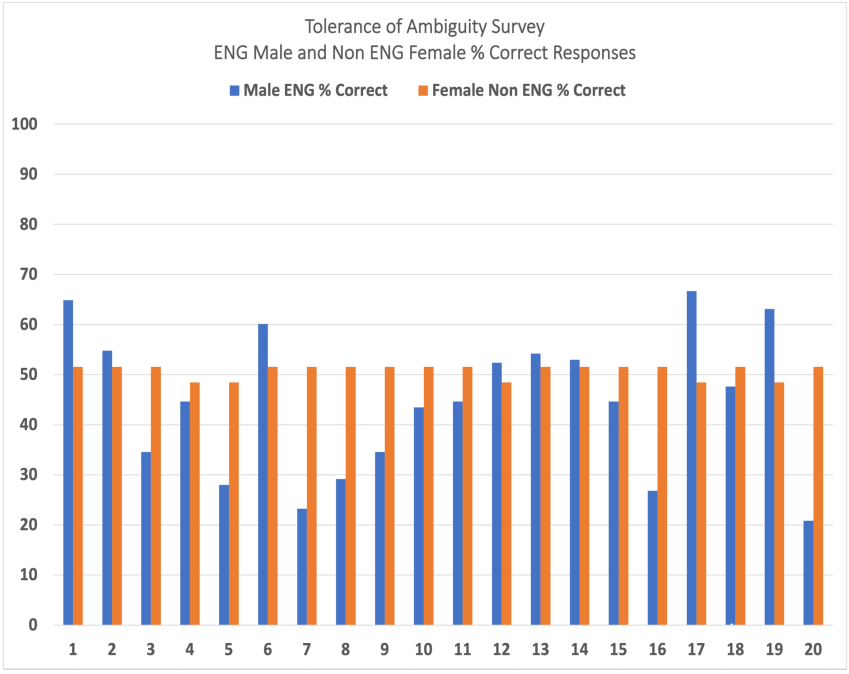

Figure 6: Comparison of male and female students

counterparts. For both engineering and non-engineering students, a higher % of the underclassmen had correct responses to half of the questions on the survey. A larger variation in the responses of the male engineering students to the items of the questionnaire was observed as compared to the female non-engineering students. This observation needs to be further studied to determine if the respondents' personality trait of extroversion has a correlation with their responses to the questionnaire. The study has provided useful insight and baseline data. It has highlighted the opportunity to increase the tolerance of ambiguity of undergraduate students. The future work entails the designing and implementing of interventions to assist the students in increasing their tolerance to ambiguity.

Acknowledgements
The research is supported by NSF Grant # 1832041.

References
[1] S. Schrader, W. M. Riggs, and R. P. Smith, "Choice over uncertainty and ambiguity in technical problem solving," *Journal of Engineering and Technology Management*, vol. 10, no. 1-2, pp. 73–99, 1993.

[2] E. Frenkel-Brunswik. "Tolerance of ambiguity as an emotional and perceptual personality variable," *Journal of Personality*, 18, 108-143, 1948.

[3] K. Durrheim, and D. Foster. "Tolerance of ambiguity as a content specific construct," *Personality and Individual Differences*, 22(5), 741-750, 1997.

[4] S. Budner. "Intolerance of ambiguity as a personality variable," *J Pers.* 1962, 30: 29-50. 10.1111/j.1467-6494.1962.tb02303.x.

[5] D. W. Tegano. "Relationship of tolerance of ambiguity and playfulness to creativity," *Psychological Reports*, 66, 1047-1056, 1990.

[6] P. Merrotsy. "Tolerance of Ambiguity: A Trait of the Creative Personality," *Creativity research journal*, 25(2), 232–237, 2013.

[7] K. Stoycheva, and K. Popova. "Tolerance/Intolerance of Ambiguity: Assessing Its Perceived Importance," *Psychological Research*, 22(3), 2019, pp 629-640.

[8] N, A. Mahmoud, S. M. Kamel, and T. S. Hamza. "The relationship between tolerance of ambiguity and creativity in architectural design studio," *Creativity studies*, [Online]. ISSN 2345-0479 / eISSN 2345-0487 2020 Volume 13 Issue 1: 179–198 https://doi.org/10.3846/cs.2020.9628 [Accessed February 6, 2022].

[9] V.E. Vynohradov, I.M. Bila, O.V. Kostyuchenko, S.V. Oborska, and L.P. Dykhnych. "Creativity, Readiness for Changes and Tolerance for Ambiguity," *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 12(3), 44-63, 2021. https://doi.org/10.18662/brain/12.3/219

[10] M. Tatzel. “Tolerance for Ambiguity in Adult College Students,” *Psychological Reports*. 47(2), 377-378, 1980. doi:10.2466/pr0.1980.47.2.377

[11] M. Buela, M. N. Joaquin, N. Tandang, and A. Bulasag. “Association of Ambiguity Tolerance and Problem-solving Ability of Students in Mathematics,” *International Journal of Sciences: Basic and Applied Research* (IJSBAR), 51(1), 12-24, 2020. [Online]. https://www.gssrr.org/index.php/JournalOfBasicAndApplied/article/view/11027

[12] K. Jaeger-Helton, and B. M. Smyser. “Switching Midstream, Floundering Early, and Tolerance for Ambiguity: How Capstone Students Cope with Changing and Delayed Projects,” *2017 ASEE Annual Conference & Exposition*, Columbus, Ohio. 10.18260/1-2—28895, 2017.

[13] S. Mohammed, G. Okudan, and M. Ogot. “Tolerance For Ambiguity: An Investigation On Its Effect On Student Design Performance,” *2006 Annual Conference & Exposition*, Chicago, Illinois. 10.18260/1-2—909, 2006.

[14] G. Geller, R. R. Faden, and D. M. Levine. “Tolerance for ambiguity among medical students: Implications for their selection, training and practice,” *Social Science and Medicine*, 31(5), 619-624, 1990. https://doi.org/10.1016/0277-9536(90)90098-D

[15] A. Weissenstein, S. Ligges, B. Brouwer, B. Marschall, and H. Friederichs. “Measuring the ambiguity tolerance of medical students: a cross-sectional study from the first to sixth academic years,” *BMC Family Practice*, 15:6, 2014. http://www.biomedcentral.com/1471-2296/15/6

[16] K. Kara and L. Kruteleva. “The relationship of ambiguity tolerance and personality traits of youth in a transitive society,” *E3S Web of Conferences 210*, 19007 (2020) ITSE-2020 https://doi.org/10.1051/e3sconf/202021019007
https://www.e3s-conferences.org/articles/e3sconf/pdf/2020/70/e3sconf_itse2020_19007.pdf

[17] A. P. MacDonald. “Revised scale for ambiguity tolerance: Reliability and validity,” *Psychological Reports*, 26, 791-798, 1970.

Appendix A

AT-20 Scale (McDonald, 1970) with ‘correct’ responses

1. A problem has little attraction for me if I don't think it has a solution (FALSE)
2. I am just a little uncomfortable with people unless I feel that I can understand their behavior. (FALSE)
3. There is a right way and a wrong way to do almost everything. (FALSE)
4. I would rather bet 1 to 6 on a long shot than 3 to 1 on a probable winner. (TRUE)
5. The way to understand complex problems is to be concerned with their larger aspects instead of breaking them into smaller pieces. (TRUE)
6. I get pretty anxious when I am in a social situation over which I have no control. (FALSE)

7. Practically every problem has a solution. (FALSE)
8. It bothers me when I am unable to follow another person's train of thought. (FALSE)
9. I have always felt that there is a clear difference between right and wrong. (FALSE)
10. It bothers me when I don't know how other people react to me. (FALSE)
11. Nothing gets accomplished in this world unless you stick to some basic rules. (FALSE)
12. If I were a doctor, I would prefer the uncertainties of a psychiatrist to the clear and definite work of someone like a surgeon or X-ray specialist. (TRUE)
13. Vague and impressionistic pictures really have little appeal for me. (FALSE)
14. If I were a scientist, it would bother me that my work would never be completed (because science will always make new discoveries). (FALSE)
15. Before an examination, I feel much less anxious if I know how many questions there will be. (FALSE)
16. The best part of working a jigsaw puzzle is putting the last piece. (FALSE)
17. Sometimes I rather enjoy going against the rules and doing things I am not supposed to do. (TRUE)
18. I don't like to work on the problem unless there is a possibility of coming out with a clear cut and unambiguous answer. (FALSE)
19. I like to fool around with new ideas, even they turn out later to be a total waste of time. (TRUE)
20. Perfect balance is the essence of all good composition. (FALSE)