Exploring Engineering Mindset

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Abstract

An optional survey instrument is used to investigate the mindset of engineering and computer-science students at a mid-sized, private university in the United States. The instrument was based on modification of prior survey instruments on mindset as well as student interpretation of talent and intelligence. With nearly 1/3 of the students responding, a significant data base was generated for student of mindset and student perceptions. In the present paper, a portion of the survey results are analyzed in an effort to explore: (i) what diversity of mindset is carried by first-year students into the university experience, (ii) how mindset evolves during the undergraduate experience, and (iii) whether differences in mindset can be identified by gender or discipline. Through multiple statistical analyses, the survey results indicate that the distribution of mindset is relatively diverse among the first-year students, but biased towards an open mindset (versus fixed mindset). There is also evidence that the mindset shifts somewhat towards fixed mindset as the students progress towards their final year. Differences in responses from students from different disciplines are noted, but no significant difference in mindset is observed by gender.

Introduction

The nature of student *mindset* is something that has remained nearly untouched in the field of engineering education. Over the years, we have discussed the nature of student beliefs, pre-existing notions of engineering students bring to the table, we have observed fascinating work on pedagogical differences leading to positive student outcomes, yet *mindset* in the form traditionally seen and debated within educational circles remains a somewhat elusive target. Educators, in particular, are interested in better understanding how students perceive their own intelligence so that programs and instructors might use that knowledge to help support learning. If students insist that intelligence and talent are fixed traits that cannot be influenced via instruction or practice, institutes of higher education become less able to promote the learning and achievement necessary in today's marketplace. Certainly, in today's engineering landscape, flexibility seems to be a requirement of the technical world, and one would hope the mindset of students could shift to better situate them for the challenges of tomorrow.

A number of authors working within the field of education theory have argued that increasing the efficacy of our educational initiatives requires a deeper understanding of student self-perceptions of their individual ability to learn, increase intelligence, and develop professional talents (e.g., Dweck, 2006; Hattie, 2002). These self-perceptions have been related to the terms "fixed mindset" and "growth mindset" as a broad means of identifying student preparedness to pursue educational objectives.

Perhaps the most significant work on mindset has been performed by Dweck (e.g., Dweck, 2007; Ehrlinger et al., 2015). In particular, Dweck has assessed the impact of these two mindsets on student learning with the fixed mindset tending to focus student learning on "documenting their intelligence or talent instead of developing them". As such, such students can be expected to exhibit a tendency to avoid difficult problems, react with greater resistance to challenges, and be motivated by goals that validate current accomplishment rather stress new learning and an associated risk of failure. In contrast, the growth mindset has been characterized by students recognizing that they can develop their talents through effort and persistence, thus encouraging more focus on active learning.

This work has led others to consider the impact of the student mindset on the resulting learning environment. Hattie (2002) for example has argued that the fixed mindset leads students to attempt to optimize their educational experience through trying to "look smart all the time and never look dumb". In contrast, the growth mindset leads to greater effort, a focus on the quality of the learning environment, and great willingness to persist despite failure. Legget (1985) relates the combination of mindset and stereotypes to differences in persistence of different student groups. Specifically, while women and men with the growth mindset persist in STEM programs in similar percentages, women exhibiting the fixed mindset persist in lower percentages than do their male counterparts. These authors argue that this lower persistence is likely a result of the combination of the fixed mindset which leads the student to believe that improvement is likely not possible in basic talent and intelligence, and societal stereotypes that send messages to young ladies in K-12 environments that they are less qualified than their male counterparts to pursue technical STEM fields. Finally, Reid and Ferguson (2014) suggest that many engineering students evolve towards greater consistency with the fixed mindset during their educational experiences.

Within the present paper, we use a survey instruments containing components adapted from the work of others (e.g., Dweck, 2007) to study the self-evaluations of students from a single university pursuing undergraduate degrees in multiple engineering and computer-science disciplines. This instrument allowed examination of a number of variables in the student learning environment. The present paper focuses on the following fundamental questions: (i) what mindsets do engineering and computer-science students carry with them while in the university setting?, (ii) does mindset depend on major group identifiers (e.g., gender, discipline)?, and (iii) is there evidence that the student mindset evolves with time at university as has been suggested in other studies?

Methodology

The Survey Instrument

The survey instrument developed for this study involve 267 total responses using a 6-point Likert scale indicating degree of agreement with a number of statements on intelligence, talent, curiosity, and creativity. The N here included approximately 30% of the total population of a school of engineering and computer science. The questions discussed within the present paper are limited to the 16 questions provided in Table 1, related to student perception on talent and intelligence, combined with demographic data.

For these questions, we were influenced by Karwowski's (2014) adaptation of Dweck's original strategy to ask questions in both a positive formulation and a negative formulation in order to test for reliability of student response. While not completely adapting Karwowski's approach of a percent "open" or "fixed," we used questions groupings where appropriate. This can be observed by comparing sequential questions in Table 1. This strategy allowed responses to paired questions to be directly compared with the expectation that distribution of responses on the first of the paired questions (positive formulation: responses 1-7) should have a similar distribution to "flipped" responses (negative formulation: responses 7-1) on the second of the paired questions. As an example, when we refer to "positive intelligence" and "negative intelligence" questions, we are referring to the sets of questions 3,5,7,8 and 1,2,4,6, respectively.

The subsequent analysis consisted of aggregate data and distribution analysis, Cronbach alpha tests, and T-tests to determine differences in distribution. Where applicable, T-tests were supplemented with Wilcoxson and other nonparametric tests to confirm statistical significance and assumptions.

Administering the Instrument

The instrument was administered at a college of engineering and computer science undergraduate program at a mid-sized (approximately 4300 total undergraduates), private, Catholic university. The engineering and computer science (BS) degrees at the host institution are housed in a common school, thus are under a single academic dean. With the exception of a small, on-line, professional master's program, the school is entirely dedicated to undergraduate education. The dean's office of the school took responsibility for producing and distributing the survey on an internet-based survey resource.

At the time of administration of the survey, the school housed approximately 850 students. In an effort to encourage broad participation in the survey, but with a desire to avoid requiring response to the survey, the dean's office used multiple emails to encourage participation. No incentives were provided for participation. Based on this strategy, 267 students responded to the survey over a period of approximately one month. Of these respondents, 251 provided answers to all questions. It is this reduced set of student responses that are analyzed. All individually identifiable information provided with the survey was removed from the data base prior to analysis of the data.

Initial Data Analysis

The resulting data were assessed predominantly from the viewpoint of comparing distributions of student responses. Of particular interest was the use of tools that allowed identification of differences in responses to multiple questions within the same student group and responses of multiple student groups to the same question. Among the tools utilized were graphical comparison of populations of responses to different questions, comparison of sample means and variances, and use of Cronbach's alpha (reference) to estimate similarity of two sample distributions.

In order to ensure consistency among all responses, any incomplete response was eliminated from the data set prior to analysis. As noted above, this reduced the data set to 251 complete responses. This reduction was considered particularly important as some response sets included a large number of non-responses, thus complicating such assessments as correlation among responses to different questions and estimation of reliability of responses.

The data analysis was applied to multiple population comparisons, including:

- Comparison of student responses relative to the positive and negative formulation pairs
- Comparison across class year
- Comparison by gender
- Comparison by discipline

In terms of reliability of the data, we employed Cronbach's as a measure of consistency across questions on intelligence and, separately, across questions on talent. The Cronbach's alpha was also applied to the full data set. The negative questions were adjusted by subtracting each response from 7, thus ensuring equivalent scale. The resulting fit between matched pairs of positive and negative formulation is interpreted as a measure of confidence in two aspects of the student responses: (1) the extent to which students are reading and interpreting individual questions; and therefore (2) the reliability of the entire data set as a reflection of student opinion.

Results of Analysis of Survey Responses

Multiple analyses were pursued relative to these data. These included basic assessment of the reliability of the data, as well as consideration of the data as separated by such groupings as gender, major, and class rank. For each of these analyses, the responses to the negative formulation questions were inverted (response subtracted from 7) so that these responses can be directly compared with the position formulation questions both visually and in terms of statistics.

Reliability of Responses

As noted above, the Cronbach's alpha is used as a measure of reliability of the student responses through comparison of the distribution of responses from similar questions in both the positive and negative formulations. When applied to the entire data set on intelligence and talent, the Cronbach's alpha results provides the values presented in Tables 2 and 3 in two formats: (1) Cronbach's alpha is first calculated within each group of positive formulation and negative formulation questions separated by intelligence and talent (Table 2), and (2) the Cronbach's alpha is then determined for all intelligence-related questions together and, separately, for the talent-related questions (Table 3). With one exception, Cronbach's alpha are all above 0.90 for the positive formulation and negative formulation questions (as separated by intelligence versus talent) as well as for all questions separated by intelligence versus talent (with modification of the negative formulation results as indicated above). Thus, these data are considered to be internally consistent among groupings of similar questions and, therefore, reliable.

Assessment of Full (Complete Response) Population

Figure 1 shows a limited number of sample plots in the realms of both intelligence and talent. As observed in these plots and reflected in the statistics provided in Table 4, there is significant variability among the individual student responses, thus likely reflecting diversity in student mindset among respondents. It is in attempting to identify and interpret this diversity that the following analysis is focused.

Examination of the values in Table 2 shows a number of interesting points. Overall, there is a high level of consistency among the responses as provided in response to the positive versus negative formulations. Further, the mean responses for the questions on intelligence were similar to those obtained for talent. In contrast, a consistently higher variance in the responses was observed for the talent questions, perhaps suggesting less uniformity of student interpretation of talent (in terms of fixed and growth mindsets) versus intelligence. This difference is discussed further below. Finally, significant skews were observed in the responses to several of the questions, suggesting a more prevalent opinion in response to these question, but a range of opinions, including those in contradiction to the primary opinion, among a smaller portion of the student population. It is pointed out that no bimodal distributions of responses were observed, suggesting that the student population did not divide into two groups representing the fixed versus growth mindsets.

These data provide a significant response to the first research question identified in the introduction, namely "what mindsets do engineering and computer-science students carry with them while in the university setting?". Review of the statistics, as well as reference to the select images provided in Figure 1 suggest that the majority of the student respondents lean towards a growth mindset (that is, they indicate at least some openness to the potential to improve in the realms of both talent and intelligence). Significantly, viewing sets of responses by respondent as in Figure 2 demonstrated a large number of students responded with values of 4 or lower for all questions (with the negative formulation questions adapted as 7 minus the response as above). A second significant set of responses showed significantly higher values (less agreement) for the talent questions than the intelligence questions. A significantly smaller number of students provided higher numbers for intelligence than for talent. Finally, only 5 responses in the final data set (252 complete responses) in which all responses were 4 or above. Thus, once again, the data set suggests an overall student mindset oriented more towards the growth mindset (change in intelligence and talent is possible) than the fixed mindset (intelligence and talent cannot be changed).

Assessment by Gender

The data were divided by gender to look for variation in mindset by major. Examples of the three types of relative response of the females versus the males are shown in Figure 3, results for question 2, 7, and 13. The histogram for question 2 shows a mode in the responses for the females at a lower value (higher level of agreement) than the mode for the males. The responses shown for question 7 demonstrate a very similar distribution for both genders. Finally, the responses for question 13 show the third type of result observed with the two genders demonstrating substantially different distributions (in this case, with the females providing a nearly uniform response over the range of 1-7. Thus, there is no consistent difference between the genders in terms of the responses; however, the data do suggest that there may be difference in the distribution of mindset among the males and females that suggest further study may provide deeper insight into the question of gender and mindset for students in engineering and computer science. Further, the gender difference was somewhat more pronounced for the questions on intelligence than for those on talent.

One example that may indicate a future pattern is that the females demonstrated consistently higher overall mean responses in the “positive response category,” indicating they are more open than fixed in that particular domain, with the exceptions of questions 7 and 8. Another interesting divergence is with questions 9, 10, and 12, where women have a higher rate of “strongly disagree” than the men, but also a lower average weighted by the percentage of “mostly disagree.” Women also have a seemingly bifurcated distribution for women in questions 1,2, and 4, indicating that among negatively worded intelligence questions, two populations of answers exist. One possible theory for the distribution skew stems from the nearly equal percentage of male respondents from all class standings, whereas females had more freshmen nearly twice as many freshmen as seniors. This skew can be interpreted by the class standing results, where we observed that students of higher class standing tend to exhibit “drift” in the system towards increasing close-minded responses. While at this N, it is impossible for us to conclude that is a statistically convergent result, the numbers thus far trend in that direction.

Assessment by Discipline

Analysis of the data by discipline is limited to consideration of Mechanical Engineering (N=106), Civil Engineering (N=56), Computer Science (N=38), and Electrical Engineering (N=26) due to the small number of respondents from the Computer Engineering and Engineering Management majors (N = 12 and 12, respectively). Shown in Figure 4, the histograms of results by major are dominated by the higher number of respondents from Mechanical Engineering. However, several observations are presented in comparing the other disciplines to Mechanical Engineering. Using both the histograms (Figure 4) and the first two moments (Table 5), the following observations are postulated.

In comparison to the Civil Engineering majors, the Mechanical Engineering majors appear to have a higher portion of their population answering in the strongly agree category for several of the questions. This can be observed in Figure 4, for example, in the results for question 3. This is also reflected in the smaller mean values observed relatively consistently for the Civil Engineering respondents as compared to those for the Mechanical Engineering respondents (Table 5). At the same time, the Civil Engineering respondents tended to have more diversity in their response than did the Mechanical Engineering respondents as observed by presence of significant Civil Engineering responses in the lower range of numbers in the histograms (for example, those shown in Figure 4 for questions 5 and 10) and in the higher variance of responses for Civil Engineering versus Mechanical Engineering respondents (Table 5).

Although the small N's make it difficult to suggest other patterns with a degree of confidence, it was noted that the Computer Science respondents were often underrepresented with respect to those who strongly agreed (positive formulation) or strongly disagreed (negative formulation) as suggested by the lack of 1's in the responses. Electrical Engineering tended to have lower results overall compared to the rest of the population.

Finally, all responses of the non-Mechanical Engineering majors are combined from direct comparison with the responses of the Mechanical Engineering majors. Motivation for this analysis is the observation that Mechanical Engineering remains the most popular engineering major at the school in this study as well as nationwide (REFERENCE). The question is therefore one of whether there is a distinct mindset difference of students in Mechanical Engineering versus students in engineering and computer science outside of this major. Within the results, as shown in the last image in Figure 4, it is observed that there is a subtle, but observable, shift in the responses of the Mechanical Engineering majors as compared to the other responses. Specifically, the mode of the response for Mechanical Engineering respondents is often at response 3, whereas that for the other respondents is 2. Further, the Mechanical Engineering respondents show disproportionate numbers of response 6 (strongly disagree) and, to a lesser extent, response 5.

Assessment by Academic Year

Finally, the data were divided by academic year in an effort to identify evolution of student response with time in program. We were concerned with the concept of "drift," wherein senior students tend to become more fixed in their mindset throughout their college experience. While the relatively large variance makes it difficult to identify statistically significant differences in the results, a number of observations are made based on histograms and basic statistics. Figure 5, for example, shows histograms for the results for questions 3, 5, and 11 for the freshmen versus senior respondents. In each case, the freshmen respondents show higher numbers of respondents strongly agreeing with the ability to change intelligence and talent (responses in the 1 or 2 categories). Further, for the questions on intelligence, there were fewer freshmen respondents strongly disagreeing with the ability to change one's personnel level of intelligence than observed for the seniors. These differences, particularly lower freshman response in terms of strongly disagreeing, were not observed as frequently for the questions on talent as they were for intelligence (e.g., as seen, for example, for question 11 in Figure 3). Thus, there is a relatively convincing change in the mindset results from the first to the last year, but this change may not be reflected as strongly with respect to student opinion on talent. Specifically, the freshman students appear more open to the possibility of changing intelligence and, to a lesser degree, talent.

An interesting second result from these data is observed in the first and, more particularly, the second order statistics. Table 6 shows these statistics for the freshmen versus the senior respondents. First, in terms of the means, the seniors tended to have higher mean responses for both intelligence and talent questions (that is, they were less convinced that intelligence and talent can be changed). Interestingly, in terms of variance of responses, the difference between the freshman and senior respondents was different for the questions on intelligence than for the questions on talent. Specifically, the senior respondents demonstrated substantially higher variability than the freshman in response to the questions on intelligence, but lower variability in response to questions on talent.

There would therefore appear to be both an overall evolution of student mindset during the four years in the programs, but also an evolution in the understanding of the relative nature of the terms "intelligence" and "talent", with the seniors showing a higher diversity in interpretation of intelligence, but a tighter distribution on the interpretation of talent.

Examining an independent T-test of our data confirms that both groups of talent questions were significantly different, yet only the positive intelligence questions were significantly different. Questions 3, and 5 differed as well – both questions belonging to the positive intelligence set of questions. We did not observe a similar significant pair in the talent sections of questions.

The pattern faced an interesting problem in the junior year, wherein junior students on questions 9,10,11,12, (or in terms of groups, negatively worded questions on talent) responded in a more open-minded way than freshmen on all of these questions. A deviation from the senior population in this case that may account for this deviation is that juniors had a lower chance of having lived in a living learning community (LLC) than seniors (17%

versus 29%). Analogously, a deviation from the freshmen is that the population of juniors is more evenly distributed across majors, while an overwhelming (51%) of freshmen indicated mechanical engineering as their concentration.

Conclusion and discussion

A survey instrument has been applied to students in the engineering and computer science undergraduate programs of a mid-sized, private, Catholic university. Response rate was approximately 30% on the voluntary completion of the relatively long survey. Within this survey, a series of sixteen questions covered multiple aspects of mindset as identified through student examination of the ability to enhance intelligence or talent.

This work is considered important to the engineering community as it is, to our knowledge, one of the first direct examinations of fixed mindset versus growth mindset in undergraduate engineering education. Within this context, the fixed mindset will result in the graduating engineer more focused on correct application of a defined set of knowledge and skill sets so as to follow, within minimal opportunity for failure, established practices in engineering industry. In contrast, the growth mindset will result in the graduating engineer more focused on extension of existing practice, with acceptance of reasonable risk of failure in new strategies to problem solution. In thinking of these two extremes in mindset, it becomes apparent that neither is a "correct" mindset for all engineering disciplines or career opportunities. However, making both faculty and students aware of this difference may provide substantial advantages in both the educational, and future career, environments.

The present study is recognized as being very preliminary. For example, the students in this particular university are selected through a relatively rigorous admission process, likely resulting in a number of impacts on the mindset of the incoming student. Further, the sample size (approximately 250 responses) is relatively limited. Despite the preliminary nature of this research, a number of observations are suggested in the results that encourage substantially broader study. Among these:

- The study appears to be internally consistent, suggesting that a survey instrument such as that used herein will provide significant value in terms of studying mindset.
- Overall, the mindset of the students appeared to be closer to a growth mindset (lower response values on the positive formulation questions), than a fixed mindset. However, there was substantial diversity in response with a diversity of student comparison between questions on intelligence versus questions on talent.
- The results suggest a possible, significant difference in mindset by gender. Specifically, the responses from the females in this study appeared to lean more towards the growth mindset than did the males. A broader understanding of such gender difference could be exceptionally valuable in designing future curricular change so as to attract more diverse student populations. In particularly, it would be extremely interesting to extend this study to multiple ethnic populations as well as to universities with broader incoming class diversity.
- While the distribution is skewed slightly for male/female responses, one possible theory for the distribution skew stems from the nearly equal percentage of male respondents from all class standings, whereas females had more freshmen nearly twice as many freshmen as seniors. This skew can be interpreted by the class standing results, where we observed that students of higher class standing tend to exhibit "drift" in the system towards increasing close-minded responses.
- The effect of living learning communities (LLCs) may come into play in mindset development. Having participated in a living learning community (LLC) had different outcomes for different populations. Having lived in a living learning community does not seem to have an effect on the distributions between males and females, with a nearly equal percent of respondents having lived in the LLC at some point in their college careers. That being said, a higher percentage of males have lived off-campus (39% to 22%,) and this is due to the higher overall standing of males in the survey.
- The reason why juniors appear to be more open-minded than seniors and freshmen as a whole merits future study. One possibility is that juniors had a lower chance of ever having lived in a living learning community than seniors or sophomores (17% compared to 24% and 29%, respectively). This interesting phenomenon may be related to a decreased enrollment overall in the LLC for their particular class year.

Also, the distribution of majors between freshmen and juniors differs to the extent that one could conclude it alone has shifted the results.

- The results suggest significant difference in mindset among the disciplines. Recognition and better understanding of these differences opens opportunities for better design of both single discipline educational experiences and curricular design to take advantage of diversity in mindset within multidisciplinary educational opportunities.
- There is initial evidence, consistent with the observation of others in the literature (REFERENCES), of a migration of the student mindset during undergraduate study. In particular, the freshman respondents seemed more willing to accept the possibility of changes in intelligence and talent than were the respondents with senior standing.
- The results provide very preliminary suggestion that the university experience may have different impact on student perception of intelligence versus talent. Recognizing how the educational experience is impacting these perceptions is likely a key to improving the educational experience and helping to create a more growth minded graduate of our programs.

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Tables

Table 1: The questions on the survey related to student mindset (as reflected in opinions on talent and intelligence)

Question Number	Positive (P) or Negative (N) Formulation?	Statement
1	N	You have a certain amount of intelligence, and you really can't do much to change it
2	N	Your intelligence is something about you that you can't change very much.
3	P	No matter who you are, you can significantly change your intelligence level
4	N	To be honest, you can't really change how intelligent you are
5	P	You can always substantially change how intelligent you are
6	N	You can learn new things, but you can't really change your basic intelligence
7	P	No matter how much intelligence you have, you can always change it quite a bit
8	P	You can change even your basic intelligence level considerably
9	N	You have a certain amount of talent, and you can't really do much to change it
10	N	Your talent in an area is something about you that you can't change very much
11	P	No matter who you are, you can significantly change your level of talent
12	N	To be honest, you can't really change how much talent you have
13	P	You can always substantially change how much talent you have
14	N	You can learn new things, but you can't really change your basic level of talent
15	P	No matter how much talent you have, you can always change it quite a bit
16	P	You can change even your basic level of talent considerably

Table 2: Statistics for the questions in Table 1 as calculated across all respondents.

Question	N	Mean	Variance	Abs(Skew)
Q1	266	4.43	1.484	0.598
Q2	265	4.34	1.552	0.544
Q3	266	2.57	1.431	0.552
Q4	267	4.49	1.296	0.576
Q5	264	2.75	1.428	0.399
Q6	265	3.92	1.528	0.285
Q7	266	2.68	1.103	0.225
Q8	264	2.71	1.149	.371
Q9	265	4.19	1.563	0.350
Q10	266	4.23	1.579	0.433
Q11	266	2.74	1.549	0.614
Q12	266	4.26	1.580	0.551
Q13	265	2.88	1.672	0.463
Q14	266	4.04	1.636	0.419
Q15	265	2.81	1.444	0.429
Q16	265	2.76	1.349	0.518

Table 3: Cronbach's Alpha values for each grouping of positive and negative formulation questions as separated by questions on intelligence versus questions on talent.

Question Grouping	Title	Cronbach's Alpha
1,2,4,6	Negative Intelligence	0.909
3,5,7,8	Positive Intelligence	0.895
9,10,12,14	Negative Talent	0.939
11,13,15,16	Positive Talent	0.920

Table 4: Cronbach's Alpha values for all questions on intelligence and all questions on talent (with appropriate modification of the negative formulation question results).

Question Grouping	Title	Cronbach's Alpha
1-8	Intelligence	0.929
9-16	Talent	0.945

Table 5: Mean and Variance based on student major.

Cohort	Statistic	Questions Related to Intelligence							
		1	2	3	4	5	6	7	8
Mechanical Engineering	Mean	2.56	2.61	2.66	2.42	2.80	3.15	2.72	2.76
	Variance	1.697	1.611	1.750	1.351	1.551	1.748	1.233	1.191
Civil Engineering	Mean	2.75	2.91	2.64	2.82	2.77	3.46	2.71	2.82
	Variance	1.645	1.683	1.470	1.568	1.454	1.308	1.117	1.240
Electrical Engineering	Mean	2.12	2.58	2.12	2.00	2.35	2.46	2.31	2.08
	Variance	1.626	2.254	1.226	1.280	1.515	1.378	1.182	1.114
Computer Science	Mean	2.34	2.39	2.45	2.32	2.79	2.68	2.82	2.84
	Variance	0.988	1.056	1.011	0.762	1.036	1.195	0.641	1.055

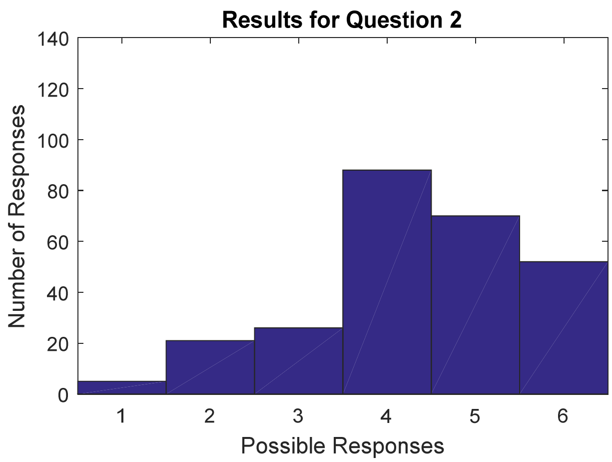
Cohort	Statistic	Questions Related to Talent							
		1	2	3	4	5	6	7	8
Mechanical Engineering	Mean	2.81	2.85	2.78	2.86	2.90	2.97	2.91	2.78
	Variance	1.469	1.634	1.714	1.570	1.675	1.533	1.534	1.505
Civil Engineering	Mean	3.23	3.00	2.98	3.04	3.11	3.29	2.95	2.88
	Variance	1.745	1.745	1.836	1.853	1.952	1.844	1.797	1.530
Electrical Engineering	Mean	2.38	2.42	2.38	2.12	2.27	2.50	2.42	2.38
	Variance	1.206	0.974	1.286	0.746	0.685	1.460	0.894	0.886
Computer Science	Mean	2.47	2.39	2.47	2.39	2.76	2.76	2.68	2.68
	Variance	1.283	1.435	1.391	1.705	1.645	1.861	1.195	1.357

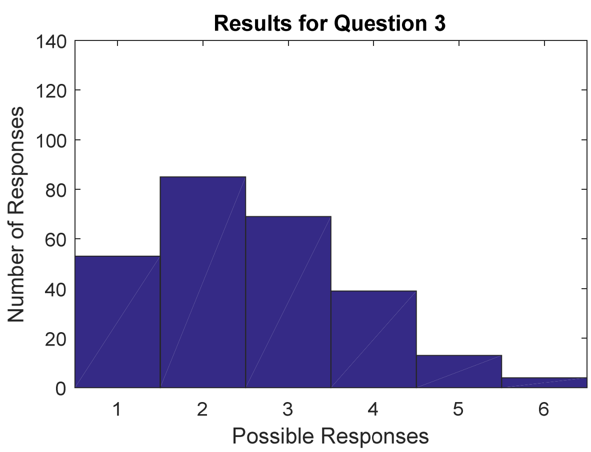
Table 6: Mean and Variance for the freshman versus senior cohorts.

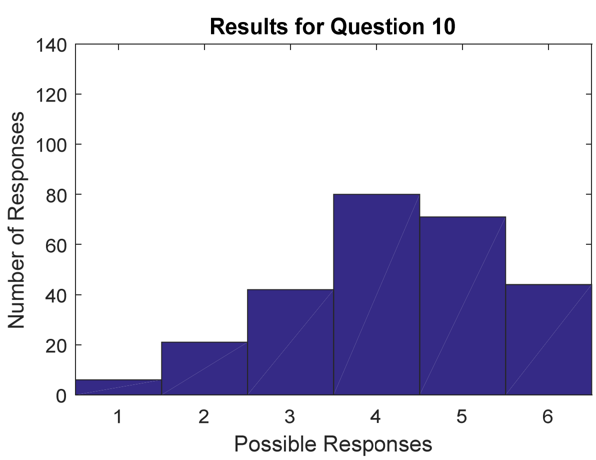
Cohort	Statistic	Questions Related to Intelligence							
		1	2	3	4	5	6	7	8
Freshman	Mean	2.55	2.55	2.31	2.40	2.54	2.97	2.46	2.57
	Variance	1.19	1.31	0.92	1.03	0.89	1.33	0.77	1.01
Senior	Mean	2.67	2.85	3.04	2.65	2.96	3.22	2.91	2.94
	Variance	1.47	1.56	1.77	1.36	1.81	1.69	1.52	1.56

Cohort	Statistic	Questions Related to Talent							
		1	2	3	4	5	6	7	8
Freshman	Mean	2.75	2.73	2.69	2.78	2.72	2.87	2.66	2.63
	Variance	1.43	1.47	1.58	1.69	1.78	1.69	1.20	1.27
Senior	Mean	3.06	2.89	2.81	2.96	3.07	3.26	2.94	2.87
	Variance	1.83	1.53	1.63	1.58	1.73	1.82	1.68	1.62

Figures


Results for Question 2
140
120
100
80
60
40
20
0
Number of Responses
1
2
3
4
5
6
Possible Responses


Results for Question 3
140
120
100
80
60
40
20
0
Number of Responses
1
2
3
4
5
6
Possible Responses


Results for Question 10
140
120
100
80
60
40
20
0
Number of Responses
1
2
3
4
5
6
Possible Responses

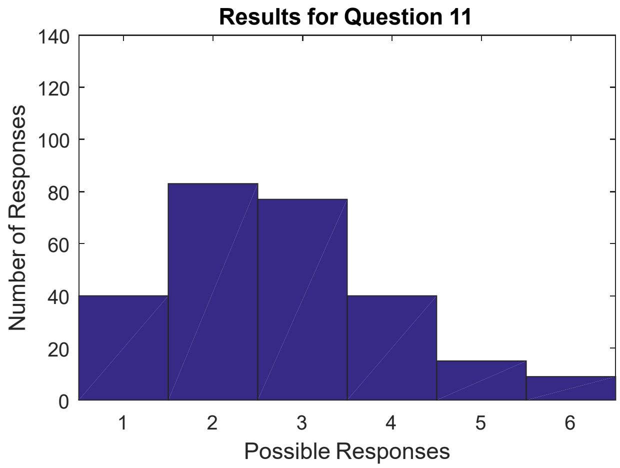
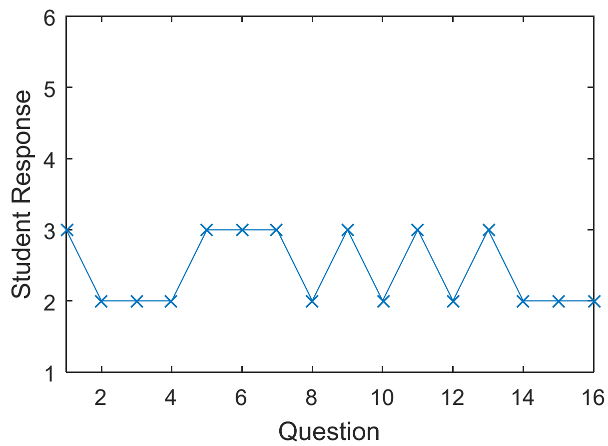
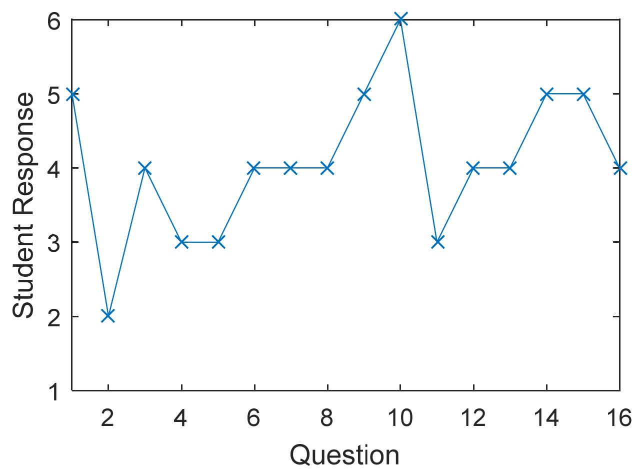
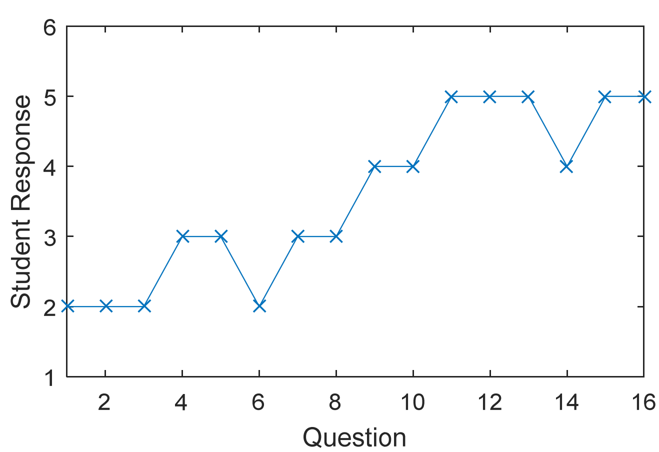


Figure 1: Example sample histograms for select questions in Table 1


Student Response
Question


Student Response
Question


Student Response
Question

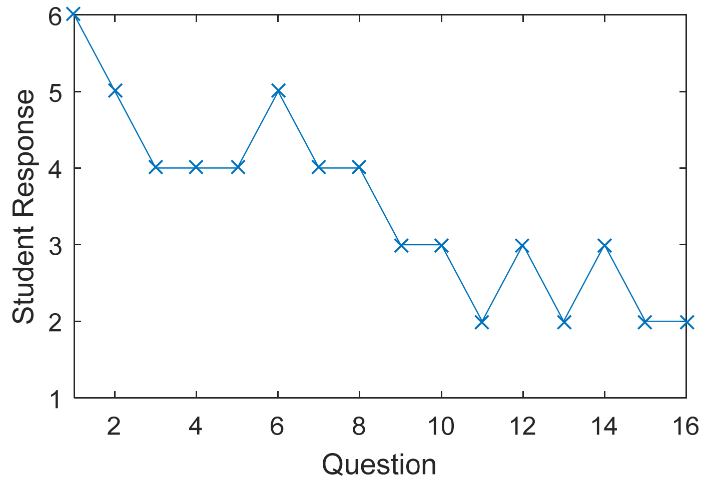
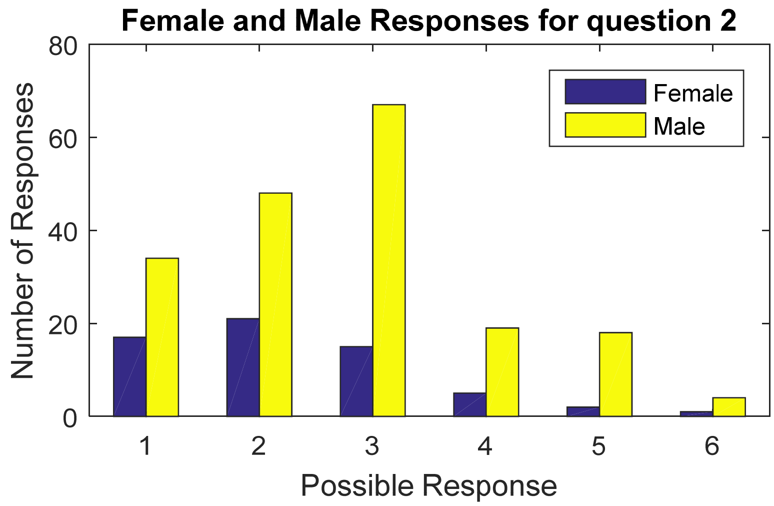
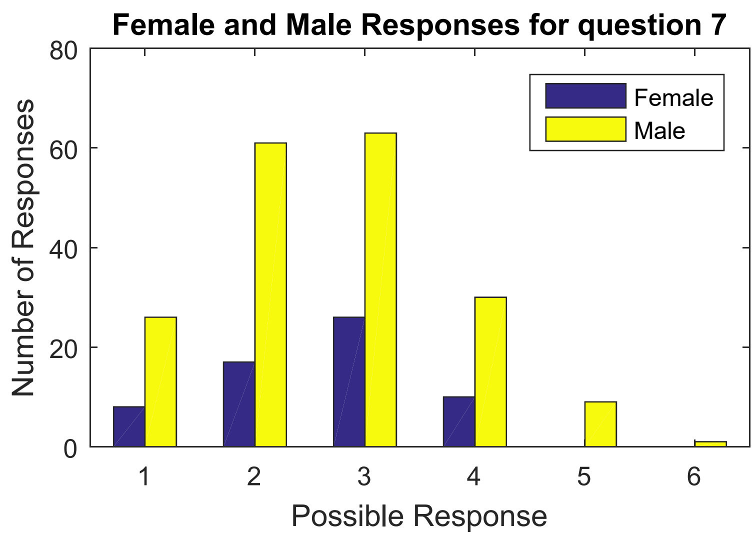


Figure 2: Examples of individual responses across the 16 questions. The largest group of responses followed a pattern similar to the first in which responses varied but were generally in the 1-3 range as in the figure 2a. Figures 2b and 2c were also relatively common in which the answers on the talent questions (9-16) showed higher values (less agreement) than those for intelligence question (1-8). A relatively rare result was that shown in figure 2d in which the respondent disagreed more (gave higher responses) to the intelligence questions than to the talent questions. In only 5 of the sets of student responses were all responses 4 or higher across all questions.


Female and Male Responses for question 2
Number of Responses
Possible Response
Female
Male
0
20
40
60
80
1
2
3
4
5
6


Female and Male Responses for question 7
Number of Responses
Possible Response
Female
Male
0
20
40
60
80
1
2
3
4
5
6

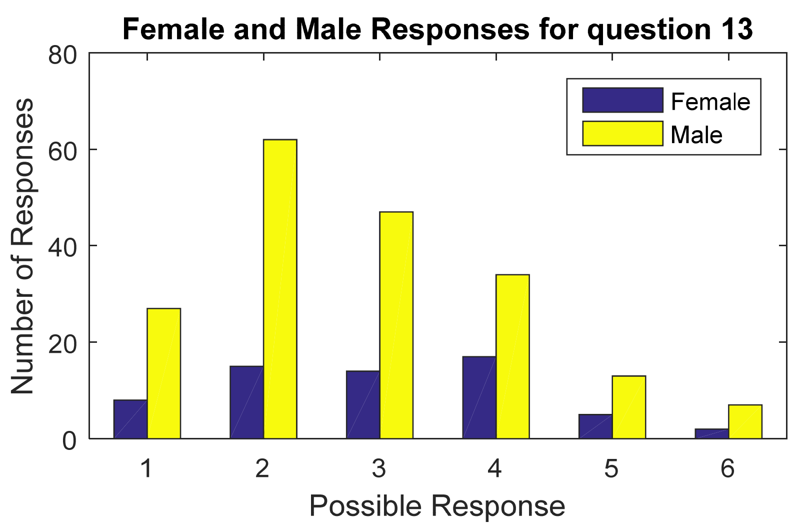
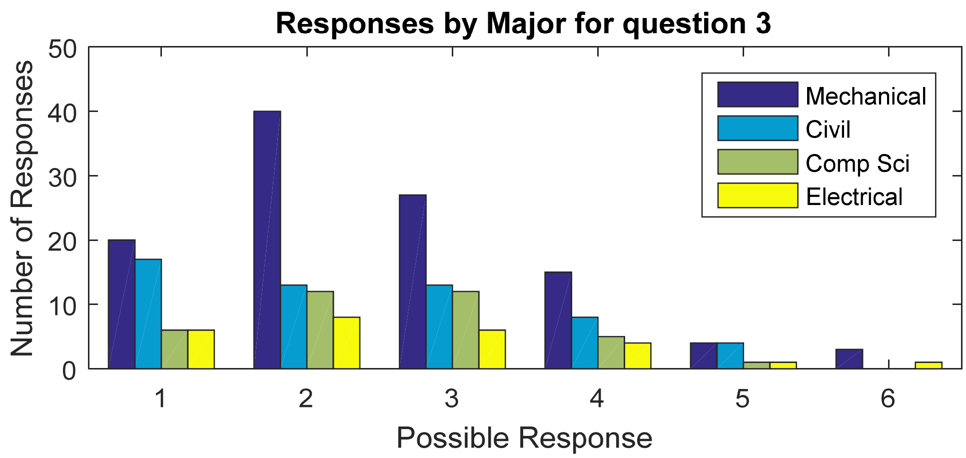
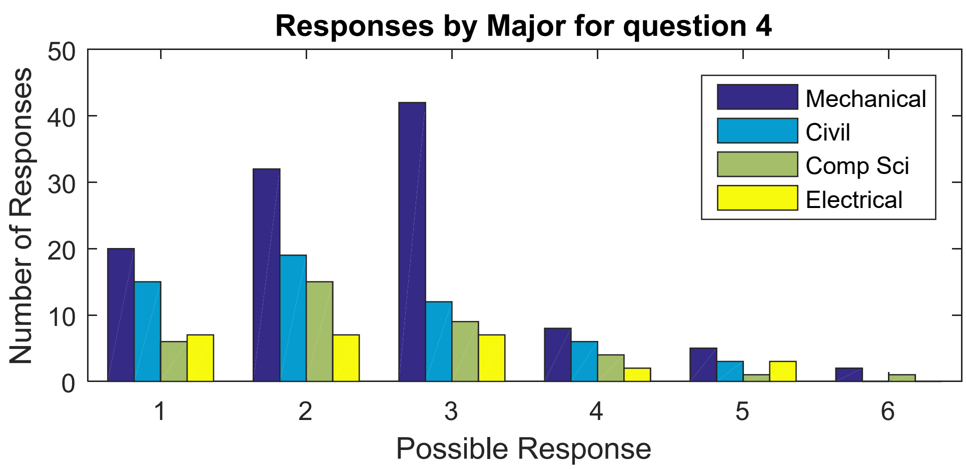
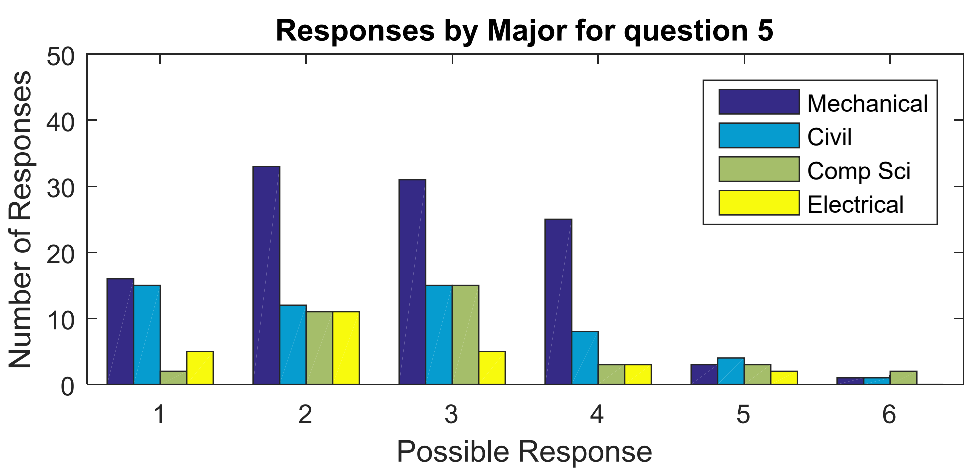
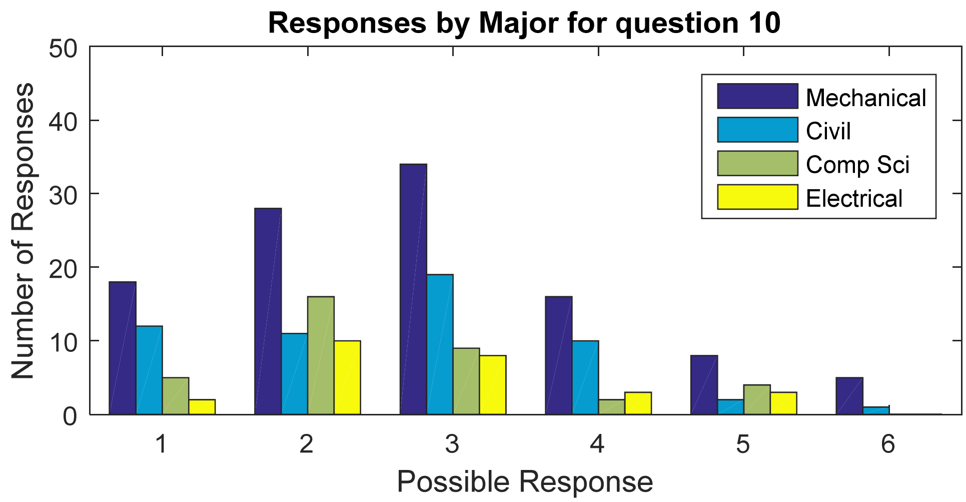

Female and Male Responses for question 13
Number of Responses
Possible Response
Female
Male
0
20
40
60
80
1
2
3
4
5
6

Figure 3: Comparison of responses by gender for the three questions 2, 7, and 13. Three types of relative responses were observed. The upper image (responses to question 2) shows an example of the responses from the women with a mode at a lower value than those for the male students (that is, the women being more positive with respect to his question). The middle image (responses to question 7) shows an example of similar responses across the two genders. The lower image (responses to question 13) shows an example in which the females responses that are shifted towards higher numbered responses (stronger disagreement) relative to the responses of the males.


Responses by Major for question 3
Number of Responses
Possible Response
Mechanical
Civil
Comp Sci
Electrical
0
10
20
30
40
50
1
2
3
4
5
6


Responses by Major for question 4
Number of Responses
Possible Response
Mechanical
Civil
Comp Sci
Electrical
0
10
20
30
40
50
1
2
3
4
5
6


Responses by Major for question 5
Number of Responses
Possible Response
Mechanical
Civil
Comp Sci
Electrical
0
10
20
30
40
50
1
2
3
4
5
6



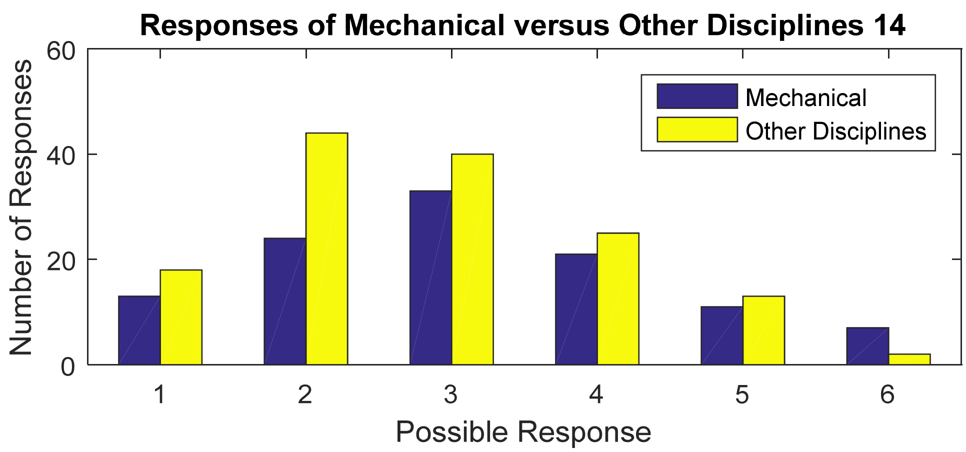


Figure 4: Comparison of responses for the Mechanical, Civil, and Electrical Engineering majors, as well as for the Computer Science majors. Computer Engineering and Engineering Management majors are not shown due to very low numbers of respondents. The last of these images is a comparison of responses from Mechanical Engineering against responses from all other disciplines combined.

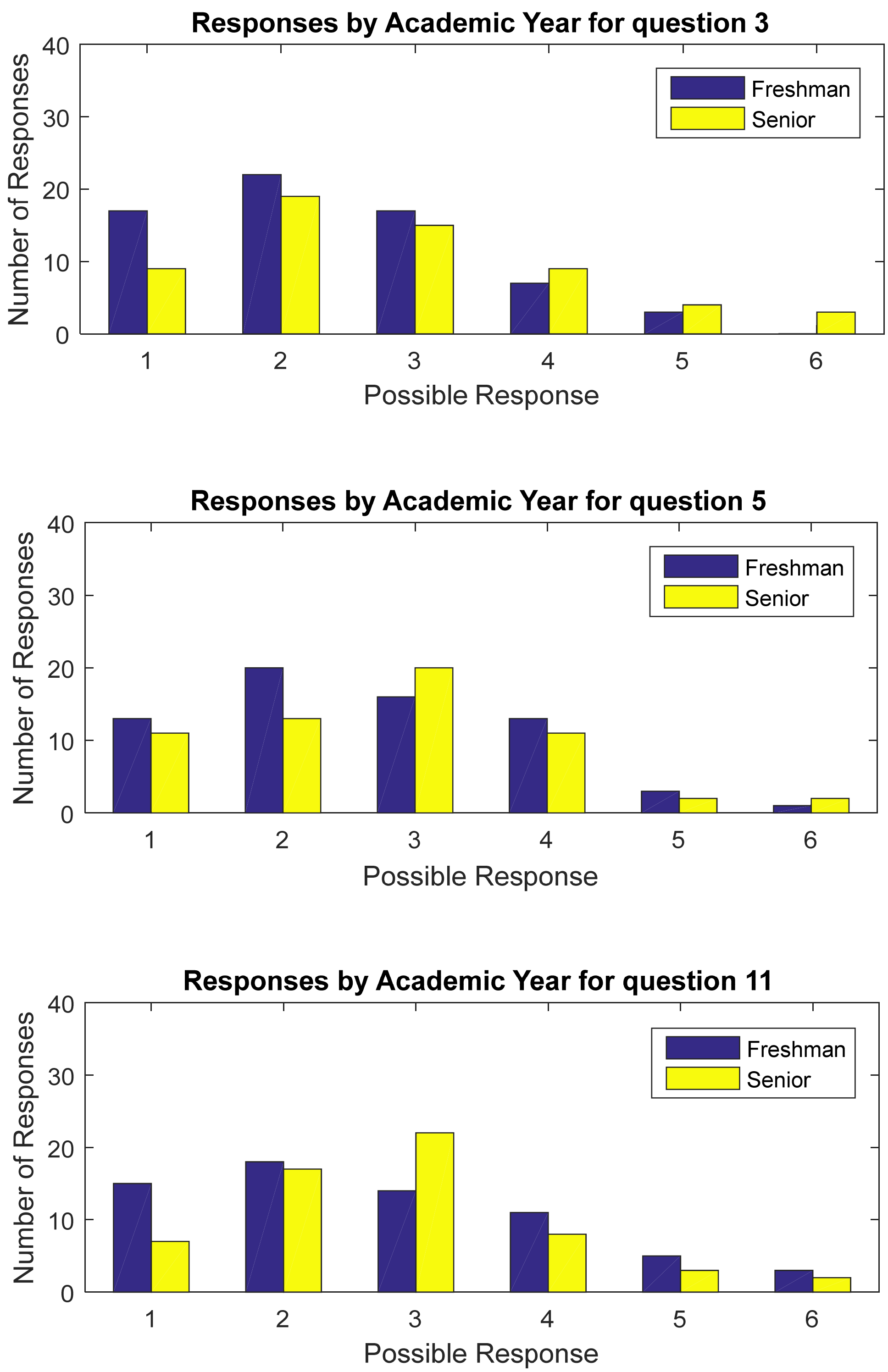


Figure 5: Comparison of responses from freshmen (N=66) and seniors (N=59) for three representative questions (3, 5, and 11). In each of these cases, a greater percentage of the freshmen indicated high level of agreement with the statements.